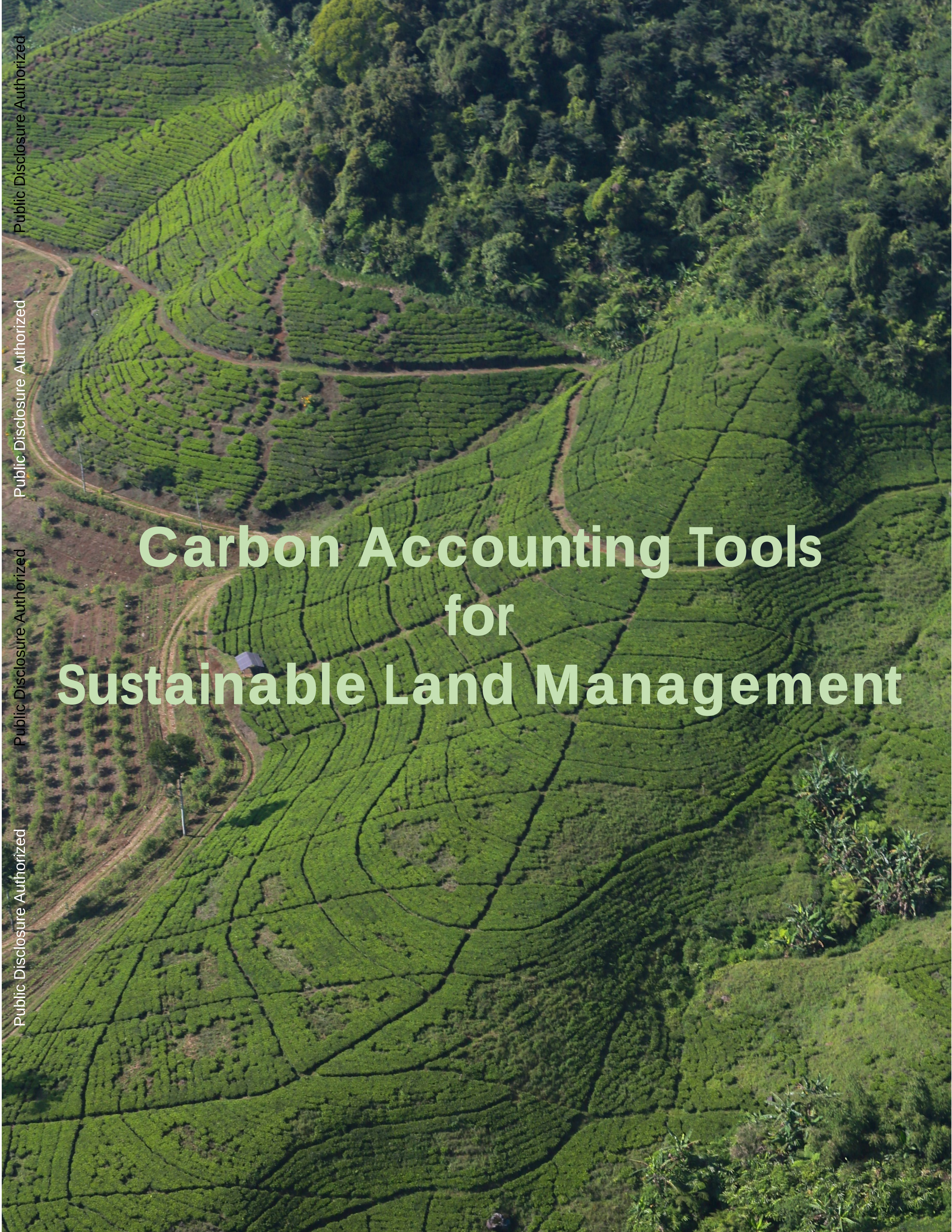
Carbon Accounting Tools for Sustainable Land Management



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Cover photo: Kate Evans/CIFOR

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Acknowledgments

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Acronyms

AFD-CFT	*Agence Française de Développement* Carbon Footprint Tool
AFOLU	Agriculture, Forestry, and Other Land Use
CAT-AR	Carbon Assessment Tool for Afforestation and Reforestation
CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza*
CAT-SFM	Carbon Assessment Tool for Sustainable Forest Management
CBP	Carbon Benefits Project
CCAFS-MOT	Climate Change, Agriculture, and Food Security Mitigation Options Tool
CDM	Clean Development Mechanism
CFT	Cool Farm Tool
CONAF	Chilean National Forestry Corporation
COP21	Conference of the Parties to the UN Framework Convention on Climate Change
CSU	Colorado State University
DA	Detailed Assessment
DNDC	De Nitrification-De Composition Model
EF	Emission Factor
EX-ACT	Ex-Ante Carbon-Balance Tool
FAO	Food and Agriculture Organization of the United Nations
FLU	Final Land Use
GEF	Global Environment Facility
GEO	Global Environment Objective
GHG	Greenhouse Gas
GZAR	Guangxi Zhuang Autonomous Region
HFC	Hydrofluorocarbon
ILU	Initial Land Use
IPA	Integrated Participatory Approach
IPCC	Intergovernmental Panel on Climate Change
IPCC-GNGGI	Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories
IPCC-GPG LULUCF	Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use, Land-Use Change and Forestry
LCA	Life Cycle Analysis
M&E	Monitoring and Evaluation
MAT	Mean Annual Temperature
NPP	Net Primary Production
PDP	Participatory Development Plan
PFC	Perfluorocarbon
SA	Simple Assessment
SF_6	Sulphur Hexafluoride

SLM	Sustainable Land Management
SLM-CCMC	Sustainable Land Management and Climate Change Mitigation Co-Benefits
SOC	Soil Organic Carbon
TARAM	Tool for Afforestation and Reforestation Approved Methodologies
USAID	U.S. Agency for International Development
VGSSM	Voluntary Guidelines for Sustainable Soil Management

Executive Summary

1) At the 21st Conference of the Parties to the UN Framework Convention on Climate Change (COP21) in Paris, in December 2015, 195 countries negotiated a binding agreement to limit global warming below 2°C compared to pre-Industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C. As global absolute greenhouse gas (GHG) emissions continue to increase, COP21 raised the sense of urgency and called for more ambitious mitigation actions. In the case of carbon dioxide (CO_2), the leading GHG contributing to temperature change, limiting the temperature increase to 1.5°C and 2°C by 2050 and 2070, respectively, would necessitate a net-zero CO_2 emissions scenario.

2) Agriculture, Forestry, and Other Land Use (AFOLU) sector is unique among economic sectors because its mitigation potential derives from both an enhancement of removals of GHGs and a reduction of emissions through management of land and livestock. The AFOLU sector is responsible for just under a quarter (approximately 10–12 $GtCO_2eq$ per year) of global anthropogenic GHG emissions, mainly due to deforestation and agricultural emissions from livestock, soil, and nutrient management. AFOLU emissions could change substantially in transformational pathways, given the high mitigation potential from agriculture, forestry, and bioenergy. Mitigation options in the AFOLU sector, therefore, need to be assessed, as far as possible, for their potential impact on all other services generated by land.

3) We cannot fix what we do not measure, which is why quantifying greenhouse gas (GHG) emissions from agricultural landscapes is a necessary step for climate-smart agriculture (CSA)[1] and sustainable land management (SLM). GHG accounting can provide the numbers and data that are key for informed decision making. It can help identify management practices and opportunities that reduce GHG emissions while also providing improved food security, more resilient production systems, and better rural livelihoods. In practical terms, GHG emissions data can support farmers in adopting less-carbon-intensive practices, guiding low-emission development, assessing product supply chains, certifying sustainable agriculture practices, and informing consumers on the carbon footprint of their choices (Olander et al. 2013).

4) This report compares the relative performance of available GHG accounting tools for SLM, defined as the implementation of land use systems and management practices that enable humans to maximize the economic and social benefits from land while maintaining or enhancing the ecosystem services that land resources provide. The report seeks to answer

[1] Climate-smart agriculture (CSA) is an integrated approach that aims to address the interlinked challenges of food security and climate change by sustainably increasing agricultural productivity to support equitable increases in farm incomes, food security, and development; adapting and building resilience of agricultural and food systems to climate change at multiple levels; and reducing greenhouse gas (GHG) emissions from agriculture.

questions such as which carbon assessment tools are available and under what conditions they are best applicable for assessing SLM GHG footprint.

5) The first step in the study identified the following 10 commonly used carbon accounting tools for further analysis:
   - Carbon Benefits Project Simple and Detailed Assessment tools developed by the GEF-funded 'Carbon Benefits Project' (**CBP SA and DA**)
   - Agence Française de Développement Carbon Footprint Tool (**AFD-CFT**)
   - Forest Carbon Calculator (U.S. Agency for International Development [USAID] Agriculture, Forestry, and Other Land Use [**AFOLU**] Carbon Calculator)
   - Carbon Assessment Tool for Afforestation and Reforestation (**CAT-AR**)
   - Carbon Assessment Tool for Sustainable Forest Management (**CAT-SFM**)
   - Climate Change, Agriculture, and Food Security Mitigation Options Tool (**CCAFS-MOT**)
   - Cool Farm Tool (**CFT**)
   - DeNitrification-DeComposition Model (**DNDC**)
   - Ex-Ante Carbon-Balance Tool (**EX-ACT**)
   - Tool for Afforestation and Reforestation Approved Methodologies (**TARAM**)

6) The tools were mapped within the wide range of potential carbon sequestration and GHG emission reduction activities, thereby developing a resource for managers of SLM projects to choose the most appropriate tool under different contexts. The study went beyond desk exercise and includes running the tools on real datasets from 18 Global Environment Facility (GEF) projects spreading across 16 countries representing a wide range of ecosystems. Many of these countries are highly dependent on the production and exports of agricultural goods and face a range of climate change-related challenges. The analyses were user-driven, to understand the underlying peculiarities of each tool and their differences, thereby enabling the users to make an informed choice on the suitable GHG calculator(s) under specific contexts.

7) The study indicates that many advanced tools have been developed, the methodologies applied by the tools are relatively similar, and tool developers align their methodology with the IPCC guidelines. The tools are moderately data, skills, and time-demanding and offer many additional functions including carbon footprint, socioeconomic analysis, and multiple area analysis. The methodologies on which the tools are based are transparent and detailed in guidance documents.

8) GHG assessment can be implemented for different reasons, depending on stakeholders and local context. Tools should be able to compare a "without project" scenario to a "with-project" situation. They should also consider pertinent issues like improving productivity and rural livelihoods, restoring degraded lands and afforestation/reforestation and forest management. A useful tool should also account for all possible mitigation options: carbon conservation, sequestration and emissions reduction, and emissions from different land

covers associated with SLM activities. The screening of the GHG tools in terms of activities scope, that is, the extent to which they can handle a wide range of SLM activities indicate that two tools: CBP and EX-ACT are the most versatile, able to address GHG emissions from non-vegetative surfaces to cropland, grassland and forest cover. CAT-AR, CAT-SFM and TARAM are the least versatile, reflecting the fact that the tools were specifically developed to address the forest sector (Table E1).

Table E1: Activity scope of GHG tools

No.	**Tool**	**Temperate crops**	**Tropical crops**	**Rice cultivation**	**Grassland**	**Livestock**	**Field trees, hedges, agroforestry**	**Perennial production (orchards, vineyards)**	**Forest**	**Wetlands**	**Settlements [2]**	**Other land[3]**	**Score (%)**	**Assessment Ratings**
1	CBP	x	x	x	x	x	x	x	x	x	x	no	91	++++
2	AFD-CFT	x	x	no	x	x	no	no	x	no	x	x	73	+++
3	AFOLU	x	x	x	x	x	x	x	x	no	no	no	73	+++
4	CAT-AR	no	no	no	no	no	no	no	x	no	no	no	9	+
5	CAT-SFM	no	no	no	no	no	no	no	x	no	no	no	9	+
6	CCAFS	x	x	x	x	x	x	x	no	no	no	no	64	+++
7	CFT	x	x	x	no	x	x	x	no	no	no	no	55	+++
8	DNDC	x	x	x	x	x	no	x	no	no	no	no	55	+++
9	EX-ACT	x	x	x	x	x	x	x	x	x	x	x	100	++++
10	TARAM	no	no	no	no	no	no	no	x	no	no	no	9	+

x means the tool meets the criterion; no means the tool does not. Score is the number of activities out of 11 for which a tool is suitable, expressed in percent. Ratings are assigned as follows:
0 % <Tool score ≤ 25 % → +
25 % < Tool score ≤ 50% → ++
50 % < Tool score ≤ 75 % → +++
Tool score > 75 % → ++++

9) Data for GHG appraisals are typically sourced during project identification up to appraisal. One of the main challenges include how to consider the heterogeneity of production systems and biological processes involved in GHG emissions; and up-scaling from the farm to a landscape assessment, all of which have implications for data needs (Colomb, 2013)[4]. At plot scale and farm scale, technical data are easily available and can be provided directly by farmers. At the regional scale, data inventory often needs to be obtained from statistical databases or expert knowledge leading to an increase in uncertainties.

[2] Settlements: This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions

[3] Other land: which includes areas with bare soil, rock, and ice, in addition to all land areas that do not fall into the other five land-use categories including degraded lands.

[4] Colomb V, Touchemoulin O, Bockel L, Chotte J L, Martin S, Tinlot M and Bernoux M 2013 Selection of appropriate calculators for landscape-scale greenhouse gas assessment for agriculture and forestry Environ. Res. Lett. Vol 8 (1) 015029

10) Seven out of the 10 tools have moderately low data requirements, one (CAT-AR) requires high amounts of data, while CAT-SFM and DNDC are notably extreme in their very high data requirements (Table E2). The time required for analysis given the availability of data varies from "very short" for CCAFS mitigation tool to "very long" for DNDC, CBP, EX-ACT and TARAM. There is close correlation between time and skill requirements for GHG analysis using the tools. Tools that are relatively highly skill-demanding, that is, require more than the basic skills, correspondingly require more time to perform GHG evaluations.

Table E2: Data, Time and Skills requirements of the tools

No.	Tool	Data requirements	Time requirements	Skills requirements
1	CBP	+++	+	++
2	AFD-CFT	+++	++	+
3	AFOLU	+++	+++	+++
4	CAT-AR	++	+++	++
5	CAT-SFM	+	++	+
6	CCAFS	+++	++++	++++
7	CFT	+++	+++	+++
8	DNDC	+	+	+
9	EX-ACT	+++	++	++
10	TARAM	+++	+	+
Legend (modified from Colomb, 2013)[5]		++++ to +; from low data requirements to medium/ high/ very high data requirements	0 min <Time necessary ≤ 10 min → ++++ 10 min <Time necessary≤ 20 min → +++ 20 min <Time necessary≤30 min → ++ Time necessary > 30 min → +	++++ to +; from basic skills requirements to /medium/high/very high skills requirements

11) The accuracy of the different quantification methods is classified in three tiers, Tier 1 methods being the least accurate. The accuracy of the method depends on the emission factors (EFs) and the project activity data used. Region-specific EFs and activity data are more accurate than country-specific EFs and should preferably be used. Nevertheless, other context-specific aspects should be considered to provide the users with tools that are comprehensible, standardized, robust, and applicable to SLM projects.

12) The report also shows that the completeness aspect is key in comparing the tools: GHG assessments are not always reported for all relevant categories of sources and sinks and GHGs. Some tools cover only some land use activities whereas other tools cover almost all land use activities. Furthermore, scope definitions vary and the number and type of GHGs covered differ across tools. As such, it is recommended to extend the scope of the calculators while restricting the data, skills, and time needed and increasing their accuracy. For international dissemination of these tools, their availability in different languages is crucial.

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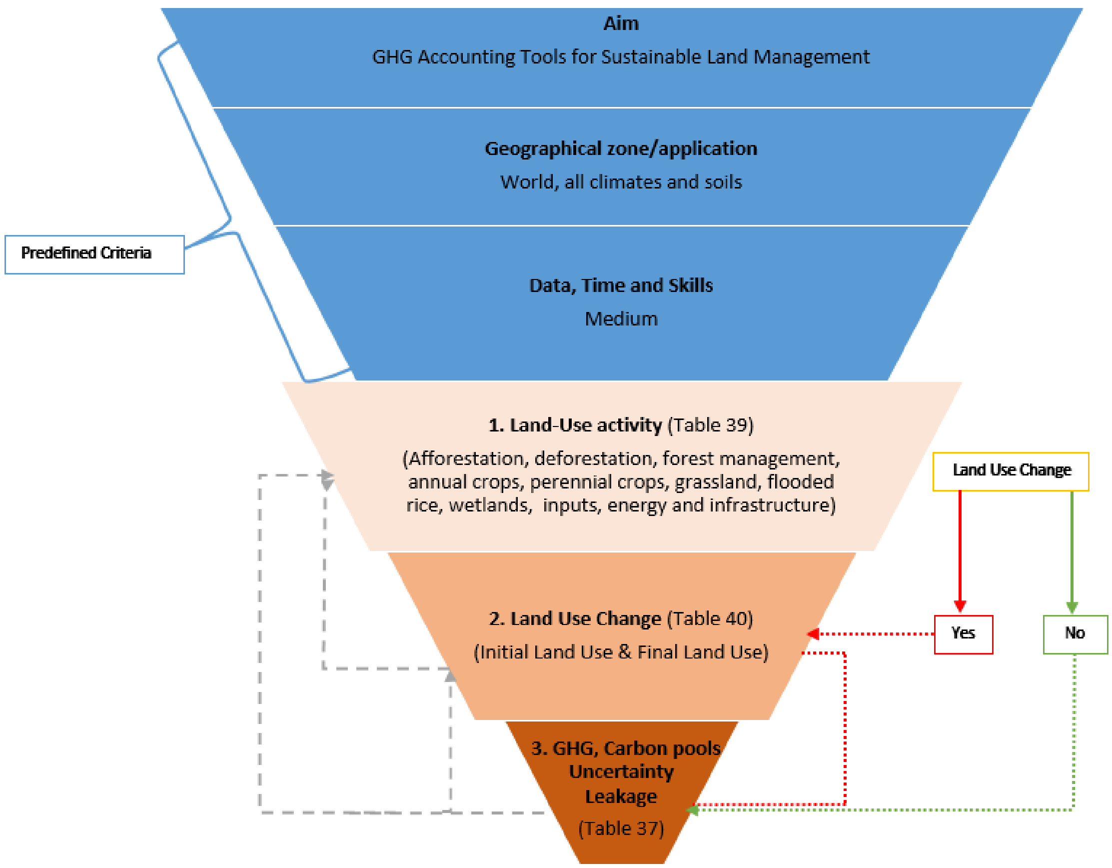
[5] Colomb V, Touchemoulin O, Bockel L, Chotte J L, Martin S, Tinlot M and Bernoux M 2013 Selection of appropriate calculators for landscape-scale greenhouse gas assessment for agriculture and forestry Environ. Res. Lett. submitted

13) The accuracy of a tool depends mainly on the data that feed into it. Thus, it depends on data availability at the local level, on the one hand, and on support of the users and advice on how to find data, on the other. All tools offer the option to specify Tier 2 values, country-specific EFs. Desk studies analysis based on project documentation is often lacking comprehensive and reliable datasets for the compilation of GHG assessment, which will decrease the level of uncertainty. Data collection and quality assurance at the local level is therefore recommended.

14) The suggested process for selecting a suitable calculator(s) is based on the characteristics of each calculator. Users should select tools according to more specific criteria, helped by the tables provided in this report.

Figure E1: Step-by-step process for selecting a GHG calculator



1. Introduction

15) Agriculture is intrinsically linked to climate, with most agricultural technologies having direct or indirect climate links. Agriculture and the patterns of land use change (LUC) that are associated with it, have a high environmental footprint and contribute to climate change, as the sector accounts for about one-quarter of anthropogenic greenhouse gas (GHG) emissions globally. At the same time, agriculture is strongly influenced by weather and climate (Battisti and Naylor 2009; FAO et al. 2017; IPCC 2001; Lobell et al. 2008).

16) Climate change poses a major challenge to the agricultural sector due to the dependence of agriculture on climate and the complex role it plays in rural, social, and economic contexts (Hatfield et al. 2011). According to the FAO (2002), the rising incidence of weather extremes will have increasingly negative impacts on crop productivity, especially if occurring at sensitive stages in crop life cycles (National Climate Assessment 2014). The Intergovernmental Panel on Climate Change (IPCC), in its fifth assessment report, predicts that climate change will affect food security substantially by the mid-21st century.

17) Yet climate-smart agriculture and sustainable land management practices such as reforestation, improved water management, integrated soil fertility management, conservation agriculture, agroforestry, better rangeland management can be major sinks, presenting opportunities to mitigate climate change by removing substantial volumes of carbon from the atmosphere and sequestering them in soils and plant tissues.

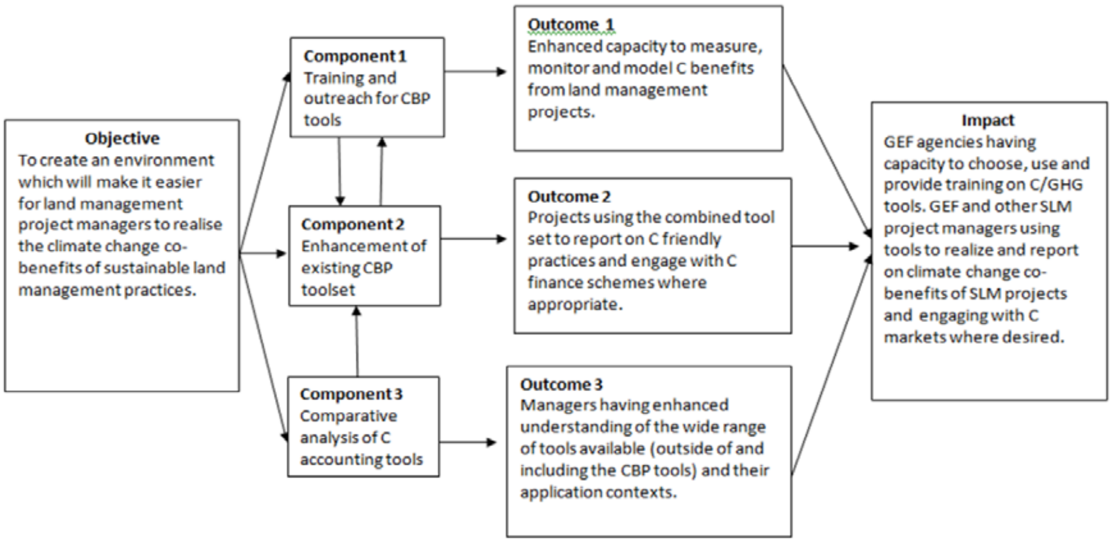
18) We cannot fix what we do not measure. Systematic assessments are required to make targeted decisions and, therefore, ensure food security. The quantification of GHG emissions and carbon sequestration is a necessary step for SLM. GHG accounting can provide the numbers and data that are key for informed decision making. It can help identify management practices and opportunities that reduce GHG emissions while also providing improved food security, more resilient production systems, and better rural livelihoods. In practical terms, GHG emissions data can support farmers in adopting less carbon-intensive practices, guiding low-emissions development, assessing product supply chains, certifying sustainable agriculture practices, and informing consumers on the carbon footprint of their choices (Olander et al. 2013).

19) Many tools have been developed for assessing GHG emissions from SLM in the last few years. Denef et al. (2012) classify these tools as calculators, protocols, guidelines, and models.[6] This report documents efforts of a study under the Sustainable Land Management and Climate Change Mitigation Co-benefits (SLM-CCMC) project financed by the Global Environment Facility (GEF) to create an environment which will make it easier for land management project managers to realize the climate change co-benefits of climate-smart

[6] Within the current study, the terms 'tools' and 'calculators' are used interchangeably.

agriculture and sustainable land management practices.[7] The project has 3 components (Figure 1): 1) Training and outreach for Carbon Benefit Project (CBP) tools; 2) Enhancement of existing CBP tools set and 3) Comparative analysis of C accounting tools (Figure 1).

Figure 1: Components of the SLM-CCMC Project



20) This report covers Component 3 implemented by the World Bank with support from the FAO and the Colorado State University. It compares the relative performance of available GHG accounting calculators for SLM, and answers questions such as which carbon assessment tools are available and under what conditions they are best applicable for assessing SLM GHG emissions. The overall goal is to provide users with helpful information for choosing the most appropriate calculator in each case, and to highlight major methodological differences between the calculators. Commonly used GHG tools are mapped within the wide range of potential carbon sequestration and GHG emission reduction activities, thereby developing a resource for the Global Environment Facility (GEF) and other managers of SLM projects to choose the most appropriate tool. The analysis goes beyond desk study and includes running the tools on real datasets from 18 GEF projects and builds on existing reviews and online tools (Colomb et al. 2013; Denef et al. 2011; Milne et al, 2013; World Bank 2012a).

[7] https://www.thegef.org/project/sustainable-land-management-and-climate-change-mitigation-co-benefits-slm-ccmc

2. Sustainable land management and carbon benefits

2.1 Sustainable land management defined

21) According to the UN Earth Summit of 1992, SLM is "the use of land resources, including soils, water, animals, and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions." It entails the implementation of land use systems and management practices that enable humans to maximize the economic and social benefits from land (soil, water, and air) while maintaining or enhancing the ecosystem services that land resources provide.

22) SLM practices include technologies and approaches that aim to increase land quality to enhance productivity and, at the same time, protect the natural resource base through economically viable and socially acceptable solutions. These technologies include agronomic, vegetative, structural, and management measures, such as new seed varieties, terracing, forestation, reduced tillage, micro-irrigation, fertilizer placement approaches, and livestock-feeding schedules.

23) There is increasing scientific evidence on the potential advantages and co-benefits associated with adopting SLM technologies and practices, including the protection of biodiversity and securing the quantity and quality of soil and water resources in the long term. Recognizing that there is no overarching solution to land degradation and low productivity, the selection of appropriate SLM practices should be site specific to ensure appropriate targeting of the root causes. Therefore, SLM technologies for a specific project area should be based on the qualities and characteristics of the local land resources; the SLM requirements of land use to be pursued; and the socioeconomic context and priorities of land users. While SLM should target the impact at the landscape level, technologies and practices are usually based on gaining incremental improvements within the land use production system by integrating local practices that will result in several benefits, including:

- Improved plant management (for example, higher yields, good vegetative cover, and reduced rain impact); [8]
- Improved soil and nutrient management (for example, higher organic matter levels; integrated plant nutrition, improved soil structure, and good rooting conditions);
- Improved rainwater management (for example, reduced runoff, increased infiltration, and improved soil moisture conditions); and
- Reduced risk to production systems, people, and assets.

[8] Annual and perennial crops, grasses, and other herbaceous pasture species, trees, and shrubs.

24) Databases such as the World Overview of Conservation Approaches and Technologies (WOCAT), TerrAfrica, the World Bank SLM Sourcebook, and the Voluntary Guidelines for Sustainable Soil Management (VGSSM) provide comprehensive recommendations and examples of SLM practices. A non-exhaustive list of SLM practices can be found in table 1.

Table 1: SLM approaches and technologies

SLM practices		
SLM approaches	**SLM technologies**	
Land use regimes	**Agronomic and vegetative measures**	**Structural measures**
• Watershed plans • Community land use plans • Grazing agreements, closures, and so on • Soil and water conservation zones • Vegetation corridors	• Intercropping • Natural regeneration of trees or other vegetation • Agroforestry • Afforestation and reforestation • No tillage • Mulching and crop residue • Crop rotation • Fallowing • Composting/green manure • Integrated pest management • Vegetative strip cover • Contour planting • Revegetation of rangelands • Integrated crop-livestock systems • Woodlots • Live fencing • Alternatives to wood fuel • Sand dune stabilization	• Terraces and other physical measures (for example, soil bunds, stone bunds, and bench terraces) • Flood control and drainage measures (for example, rock catchments' water harvesting, cut-off drains, vegetative waterways, stone-paved waterways, flood water diversion, and so on) • Water harvesting, runoff management, and small-scale irrigation (for example, shallow wells/boreholes, micro ponds, underground cisterns, percolation pits, ponds, spring development, roof water harvesting, river bed dams, stream diversion weir, farm dam, tie ridges, inter-row water harvesting, half-moon structures, and so on) • Gully control measures (for example, stone check dams, brushwood check dams, gully cut/reshaping and filling, gully revegetation, and so on)

2.2 Carbon benefits of SLM projects

25) SLM has the potential to deliver carbon benefits in three important ways (World Bank, 2012b):

- The first is through carbon conservation, in which the large volumes of carbon stored in natural forests, grasslands, and wetlands remain stored as carbon stocks. Conserving this terrestrial carbon represents a 'least-cost opportunity' in terms of climate change adaptation and mitigation and is essential to increasing the resilience of agricultural ecosystems.
- The second is through carbon sequestration, in which the growth of agricultural and natural biomass actively removes carbon from the atmosphere and stores it in soil by increasing soil organic carbon (SOC) and biomass (both above and below the ground).
- The third is through the reduction of GHG emissions that emanate from agricultural production, including those emissions that result from land use change (LUC) in which carbon stocks become carbon sources as agricultural production expands into natural ecosystems. The potential and magnitude of each of these benefits depend on

the baseline conditions and on the local environmental, socioeconomic, and cultural conditions.

26) Understanding the potential for SLM technologies and practices to mitigate GHG emissions in the agriculture sectors requires cost-effective tools that can assess total-system carbon benefits. Estimates of this potential should consider the full GHG balance, including possible combinations of different activities and practices that could affect the net climate change mitigation potential. Such tools should be comprehensible, standardized, robust, and applicable to SLM projects, policies, and strategies. In the last few years, several carbon accounting tools have been developed following different approaches to meet the needs of various users.

2.3 Methodology for the study

27) This study is designed to compare the relative performance of available GHG accounting tools[9] and help potential users select the most appropriate tool(s) for an SLM project's GHG assessment. It seeks to answer questions such as which carbon assessment calculators are available and under what conditions they are best applicable for assessing the SLM GHG emissions.

28) To facilitate the different activities of targeting climate change mitigation in agriculture, decision makers can currently choose from a wide range of available GHG tools. Many tools have been developed for assessing GHG emissions from SLM activities in the last few years. These tools differ in their main objectives—reflected in different data needs, geographical scope, and coverage along the value chain, as well as their regional and subsector specificity. Each tool is characterized by certain competitive advantages and is often the first methodological choice with regard to its own field of specialization.

29) The tools selection builds on the outcome of Colomb et al. (2012, 2013) studies and the documentation provided with each calculator. Six prescreening criteria were applied: availability, geographical coverage, activities scope, data requirements, time requirements, and skills requirements. Out of the 10 prescreened tools, the 7 tools with the highest global screening scores were selected for the comparative analysis and, therefore, for real project datasets' evaluation. The short-listed tools were further explored in terms of how they can be used; types of activities considered; GHG assessment boundary; carbon pools, sources, and sinks; associated GHG emissions; and other relevant criteria. The testing of the tools goes beyond a desk exercise and includes running the tools on real datasets from GEF projects. Eighteen SLM projects were identified and analyzed using the seven short-listed tools. Two projects were subject to field data collection and are used as case studies for an in-depth assessment of each tool.

[9] In this report, the terms 'tools' and 'calculators' are used interchangeably.

30) Based on the tools' scope and the IPCC GHG accounting approaches, 51 activities were assessed and eight main SLM activities were identified. The selected projects represent the implementation of land use systems and management practices across a wide spectrum of SLM technologies. Countries were selected to represent a range of ecosystems (for example, tropical, temperate, and semi-arid) and agro-ecological zones representing five regions (Africa, Middle East and North Africa, Latin America and the Caribbean, Eastern Europe and Central Asia, and Europe). Results obtained by project/activity were analyzed and discussed. Standard deviation was used to measure variation or dispersion between values in a set of results data, providing an indication of how far the tools' individual responses to a set of data vary or 'deviate' from the mean. Critical variables were identified, which allowed conclusions to be drawn on the relative transparency, completeness, and consistency of each tool.

3. Screening of carbon accounting tools

3.1 Carbon tools identification and characterization

31) GHG calculators have been developed through different approaches, targets, and objectives, suitable for a defined geographic coverage. To facilitate the different activities of targeting climate change mitigation in agriculture, decision makers can today choose from a wide range of available GHG tools. The first step in this analysis identified the following carbon accounting tools for further analysis:
    - Carbon Benefits Project Simple and Detailed Assessment tools developed by the GEF-funded 'Carbon Benefits Project' (**CBP SA and DA**)
    - Agence Française de Développement Carbon Footprint Tool (**AFD-CFT**)
    - Forest Carbon Calculator (U.S. Agency for International Development [USAID] Agriculture, Forestry, and Other Land Use [**AFOLU**] Carbon Calculator)
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    - Tool for Afforestation and Reforestation Approved Methodologies (**TARAM**)

32) These tools differ in their main objectives—reflected in different data needs, geographical scope, and coverage along the value chain as well as their regional and subsector specificity. Each tool is characterized by certain competitive advantages and is often the first methodological choice with regard to its own field of specialization.

33) To facilitate a more informed tool selection, the tools selection builds on the outcome of Colomb et al. (2012, 2013) studies by applying the following six prescreening criteria:
    - **Availability.** This criterion allows us to evaluate whether the tool and its technical guidelines are freely accessible online (see Table 2).
    - **Geographical coverage.** This criterion allows us to evaluate the geographical context, that is, the continental regions where the tools are mostly applicable. (See Table 2).
    - **Activities scope.** This allows us to evaluate to what extent the tools can handle a wide range of SLM activities (see Table 3).
    - **Data requirements.** This refers to the data that the GHG analysis is based on. This may be data available to the user before the evaluation begins or intermediate data that are generated during the analysis. Data requirements are assessed in terms of qualitative and quantitative information (for example, state of degraded forests) and the relative accessibility of the data, especially in a developing country context (see Table 4).

- **Time requirements.** This refers to the time it takes for the user to successfully conduct an analysis. Note, however, that it may be difficult to precisely estimate the amount of time necessary for each tool or assessment, as this depends on the skills of the evaluator, level of accuracy, reliability, and data availability (see Table 4).
- **Skills requirements.** This indicates the extent to which skills needed for the analysis exceed what we consider basic evaluation skills. Such basic skills include the ability to reason logically and conduct basic GHG analysis, gather information through interviews and other qualitative methods, and write reports and present results. Without appropriate skills, impractical or inappropriate methodology may be selected, resulting in misleading conclusions. The special skills needed for conducting the different types of efficiency analyses presented in this report are agronomic, forestry, or SLM skills (see Table 4).

3.1.1 Availability and geographical coverage

34) All the 10 tools screened are readily available online and offer technical guidance for users. Table 2 shows the website, developer, and geographic coverage of each tool. The tools are web or Excel-based, are freely available on the Internet and can be downloaded directly or accessed through e-mail requests from the developers. Tool descriptions are usually generated on the website, and sometimes include case study applications. While most of the tools were developed in countries with industrial agricultural systems, researchers and users have been able to adapt them to development projects in countries where agriculture and SLM are key priorities.

Table 2: Website, developer, and geographical coverage of the carbon accounting tools

No.	Tool	Website	Developer	Geographical zone/application
1	AFD-CFT	http://www.afd.fr/lang/en/home/projets_afd/changement_climatique/Liens_utiles_climat/4861736956	*Agence Française de Développement* (France)	World *All climates*
2	AFOLU Carb	http://www.afolucarbon.org/	USAID, Winrock International (United States)	World *All climates*
3	CAT-AR	http://www.worldbank.org/en/search?q=CAT-AR+percent28Carbon+Assessment+Tool+for+Afforestation+and+Reforestation percent29	World Bank	World *All climates*
4	CAT-SFM	http://documents.worldbank.org/curated/en/392001468331049999/pdf/903680WP0Box380tingguidanceforestry.pdf	World Bank	World *All climates*
5	CBP	www.carbonbenefitsproject.org	GEF/United Nations Environment Programme / Colorado State University (CSU)	World *All climates*
6	CCAFS-MOT	https://ccafs.cgiar.org/mitigation-option-tool-agriculture#.V717mU19670	CGIAR CCAFS	World *All climates*

No.	Tool	Website	Developer	Geographical zone/application
7	CFT	https://www.coolfarmtool.org/	Unilever and researchers at the University of Aberdeen	World *All climates*
8	DNDC	http://www.dndc.sr.unh.edu/	Institute for the Study of Earth, Oceans, and Space, University of New Hampshire (United States)	United States, but has been adapted to other parts of the world *Temperate climate to a large extent*
9	EX-ACT	http://www.fao.org/tc/exact/ex-act-home/en/	FAO	World *All climates*
10	TARAM	https://wbcarbonfinance.org/Router.cfm?Page=BioCF&FID=9708&ItemID=9708&ft=DocLib&CatalogID=44969	World Bank Carbon Finance Unit	World *All climates*

3.1.2 Activities scope

35) GHG assessment can be implemented for different reasons, depending on the stakeholders and the local context. There is a need for carbon accounting tools that are capable of cross comparing 'without-project' and 'with-project' scenarios while at the same time addressing pertinent issues such as improving agricultural productivity, strengthening the resilience of rural livelihoods, and restoring degraded land resources. Furthermore, a useful tool should also account for all possible mitigation options: carbon conservation, sequestration, and emission reduction.

36) According to the IPCC, GHG emissions reporting is addressed along the following six land use categories:
    - **Forestland.** This category includes all land with woody vegetation consistent with thresholds used to define forestland in the national GHG inventory. It also includes systems with a vegetation structure that currently falls below but in situ, could potentially reach the threshold values used by a country to define the forestland category.
    - **Cropland.** This category includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the forestland category.
    - **Grassland.** This category includes rangelands and pasture land that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the forestland category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, consistent with national definitions.
    - **Wetlands.** This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (for example, peatland) and that does not fall into the forestland, cropland, and grassland or settlements categories. It includes

reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.

- **Settlements.** This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.
- **Other land.** This category includes areas with bare soil, rock, and ice, in addition to all land areas that do not fall into the other five land use categories including degraded lands.

37) The scope of activities of the tools is indicated in Table 3, ranging from ability to assess GHG emissions from non-vegetative surfaces to cropland, grassland, and forest cover. The CBP and EX-ACT were identified as the most versatile tools capable of addressing most, if not all, land use activities. The least versatile tools identified where the CAT-AR, CAT-SFM, and TARAM, because they were developed to address the forestry sector.

Table 3: Activity scope for the tools

No.	Tool	Temperate crops	Tropical crops	Rice cultivation	Grassland	Livestock	Field trees, hedges, agroforestry	Perennial production (orchards, vineyards)	Forest	Wetlands	Settlements [10]	Other land[11]	Score (%)	Assessment Ratings
1	CBP	x	x	x	x	x	x	x	x	x	x	no	91	++++
2	AFD-CFT	x	x	no	x	x	no	no	x	no	x	x	73	+++
3	AFOLU	x	x	x	x	x	x	x	x	no	no	no	73	+++
4	CAT-AR	no	no	no	no	no	no	no	x	no	no	no	9	+
5	CAT-SFM	no	no	no	no	no	no	no	x	no	no	no	9	+
6	CCAFS	x	x	x	x	x	x	x	no	no	no	no	64	+++
7	CFT	x	x	x	no	x	x	x	no	no	no	no	55	+++
8	DNDC	x	x	x	x	x	no	x	no	no	no	no	55	+++
9	EX-ACT	x	x	x	x	x	x	x	x	x	x	x	100	++++
10	TARAM	no	no	no	no	no	no	no	x	no	no	no	9	+

x means the tool meets the criterion; no means the tool does not. Score is the number of activities out of 11 for which a tool is suitable, expressed in percent. Ratings are assigned as follows:
0 % <Tool score ≤ 25 % → +
25 % < Tool score ≤ 50% → ++
50 % < Tool score ≤ 75 % → +++
Tool score > 75 % → ++++

[10] Settlements: This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions

[11] Other land: which includes areas with bare soil, rock, and ice, in addition to all land areas that do not fall into the other five land-use categories including degraded lands.

3.1.3 Data requirements

38) Data for GHG appraisals is typically sourced during the project identification phase through the project appraisal process. The main challenges for the data needs of GHG assessments of SLM projects is the heterogeneity of production systems and biological processes involved in GHG emissions and the scaling-up of assessments from the farm to landscape level (Colomb et al. 2013). At plot and farm scale, technical data are more readily available and can be generated directly by farmers, while at the regional scale, data often need to be obtained from a statistical database or through expert knowledge, often increasing uncertainties.

3.1.4 Time and skills requirements

39) Seven out of ten tools have moderately low data requirements. CAT-AR requires a high amount of data, while CAT-SFM and DNDC are notably higher in their data requirements (Table 4). The time required for analysis, given the availability of data, varies from ‘very short’ for the CCAFS-MOT to ‘very long’ for the DNDC, CBP, EX-ACT, and TARAM tools. There is close correlation between time and skills requirements for GHG analysis using the tools. Tools that are relatively highly skill-demanding, that is, they require more than the basic skills previously mentioned for assessments, correspondingly require more time to perform GHG evaluations.

Table 4: Data, time, and skills requirements of the tools

No.	Tool	Data requirements	Time requirements	Skills requirements
1	AFD-CFT	+++	++	+
2	AFOLU Carb	+++	+++	+++
3	CAT-AR	++	+++	++
4	CAT-SFM	+	++	+
5	CBP	+++	+	+
6	CCAFS-MOT	+++	++++	++++
7	CFT	+++	+++	+++
8	DNDC	+	+	+
9	EX-ACT	+++	++	++
10	TARAM	+++	+	+
Legend (modified from Colomb et al. 2013)		++++ to +; from low data requirements to medium/high/very high data requirements	0 min < Time necessary ≤ 10 min → ++++ 10 min < Time necessary ≤ 20 min → +++ 20 min < Time necessary ≤ 30 min → ++ Time necessary > 30 min → +	++++ to +; from basic skills requirements to medium/high/very high skills requirements

3.1.5 Conclusion and remarks

40) All the tested tools are readily available online and have technical guidance. CBP and EX-ACT are identified as the most versatile by nature because they cover all land use activities. CAT-AR, CAT-SFM, and TARAM are the least versatile, reflecting the fact that the tools were specifically developed to address the forestry sector. Seven tools have moderately low-data requirements, one (CAT-AR) requires high amounts of data, while CAT-SFM and DNDC have very high data requirement.

41) The overall prescreening results are presented in Table 5. Four criteria were considered in the final ratings, as there is no significant difference among the tools in terms of availability and geographic coverage. CCAFS-MOT achieved the highest rating of 81 percent. It can handle many activities, and it is relatively low in data, time, and skills requirements. AFOLU Carb and CFT each received a global screening score of 75 percent, followed by EX-ACT with a score of 69 percent and CBP with a score of 62 percent. Five tools (CBP, AFD-CFT, CAT-SFM, DNDC, and TARAM) are highly skill-demanding, with the implication that more training may be required for users. Alternatively, developers could explore the possibility of simplifying the tools to encourage a larger number of users. The most time-demanding tools identified are the CBP, DNDC, and TARAM because the data and skills requirements are high.

Table 5: Prescreening results of 10 tools

No.	Tool	Activities scope	Data requirements	Time requirements	Skills requirements	Global screening score[a] (%)
1	AFD-CFT	+++	+++	++	+	56
2	AFOLU Carb	+++	+++	+++	+++	75
3	CAT-AR	+	++	+++	++	50
4	CAT-SFM	+	+	++	+	31
5	CBP	++++	+++	+	++	62
6	CCAFS-MOT	+++	+++	++++	+++	81
7	CFT	+++	+++	+++	+++	75
8	DNDC	+++	+	+	+	38
9	EX-ACT	++++	+++	++	++	69
10	TARAM	+	+++	+	+	37

Note: a. Global prescreening score is the number of points (+) out of a maximum of 16, expressed in percentage.

42) Apart from the activities scope, the DNDC scored low on all other screening criteria. The DNDC is simulation model based, lacking the interface (automated web or Excel) characteristic of most other tools. In addition to its highly demanding time and skills requirements, the CAT-SFM's primary focus on assessing the net anthropogenic GHG removals by sinks and emissions in forest management activities gives it a limited activities scope.

43) Out of the 10 prescreened tools, 7 tools with the highest global screening scores were selected for the comparative analysis. In descending order of score, the selected tools are CCAFS-MOT, AFOLU Carb, CFT, EX-ACT, CBP Tools, AFD-CFT, and CAT-AR. More detailed information on the three tools with the lowest ratings are presented in Table 6.

Table 6: Detailed information on the three unsuitable tools

Tools	CAT-SFM	DNDC	TARAM
General Information	CAT-SFM closely follows the Guidance for AFOLU Projects by the Voluntary Carbon Standard (VCS Association 2008) to assess the net anthropogenic GHG removals by sinks and emissions by sources resulting from forest management activities. Assessment level: Site level Geographical coverage: Global Practices covered: Forest Management GHG covered: CO_2, N_2O, and CH_4	DNDC tool can be used for predicting crop growth, soil temperature and moisture regimes, soil carbon dynamics, nitrogen leaching, and emissions of trace gases including N_2O, nitric oxide (NO), nitrogen (N_2), ammonia (NH_3), CH_4, and CO_2. Assessment level: Site level Geographical coverage: United States. Practices covered: Mainly crops; can quantify emissions from a variety of specific crop management practices. GHG covered: CO_2, N_2O, and CH_4	TARAM is an Excel-based spreadsheet that facilitates the estimation of ex ante emission reductions either Temporary Certified Emission Reductions (tCERs) or Long Certified Emission Reductions (lCERs) according to the steps prescribed in the A/R methodologies. Assessment level: Site level Geographical coverage: Global Practices covered: Forest Management, afforestation and reforestation activities. GHG covered: CO_2, N_2O, and CH_4
Data input	• Description and number of stands, measurement units, and project year • Baseline, management activities (application of fertilizers, liming application, thinning and harvesting, solid and paper wood products, wood to be burned, fossil fuel consumption within the forest stand) • Project activity (use of fertilizers, liming, thinning, and harvesting, paper wood products, wood to be burned) • Leakage and key default values	• Daily temperature and precipitation • Soil bulk density, texture, organic carbon content, pH • Farming practices (for example, crop type and rotation, tillage, fertilization, manure amendment, irrigation, flooding, grazing, and weeding)	• Methodology applicable to the proposed Clean Development Mechanism (CDM)-AR project activity • Description of stands (tree and woody species) • Baseline stratum and project activities (stratum, sub-stratum, plot location, number of trees, diameter at breast height, tree height, wood density, biomass expansion factor, root-shoot ratio, merchantable volume, fuel use, fertilizer use, area of biomass burned) • Leakage and key default values
Data Output	• Carbon stocks (tCO_2eq): this encompasses all stand models and every year, and the carbon contained in (above-ground and below-ground) woody vegetation, in (above-ground and below-ground) pre-existing trees and woody vegetation and in solid wood and paper products • Sum of changes in carbon stocks, above-ground and below-ground (tCO_2eq) • Losses, above-ground and below-ground (tCO_2eq)	• Daily dynamics in the simulation run tab • Annual results per hectare in the results tab: crop production (kg C per ha per year), N balance (kg N per ha per year), C balance (kg C per ha per year), water balance (mm per year), and GHG emissions (kg CO_2eq per ha per year)	• Ex ante net anthropogenic GHG removals by sinks • Anticipated volume of carbon credits

Tools	CAT-SFM	DNDC	TARAM
	• Emissions (tCO_2eq) from use of fossil fuel, from liming and fertilization, from burning and decay of wood and wood products in all stand models		
Potential use of the tool	• The CAT-SFM does not consider fire occurrence resulting in forest degradation and focuses only on the forest management-oriented projects. • The need for detailed data makes the use of the tool a challenge (fertilization, liming application, thinning and harvesting, solid and paper wood products, fossil fuel consumption within the forest stand, and so on).	• The tool can be used for predicting crop growth, soil temperature and moisture regimes, soil carbon dynamics, nitrogen leaching, and emissions of trace gases. • The tool is not adapted to estimate GHG emissions from agricultural development projects, where we mostly compare a baseline scenario to a 'with-project' scenario. • The geographical coverage is limited to the United States.	• The TARAM Tool was designed by the World Bank team as a self-explaining tool suitable Afforestation/Reforestation approved methodologies. It starts by choosing a methodology from the approved and available methodologies' list and the model automatically adapts all the worksheets to each methodology's particularities.

4. Short-listed tools for comparative analysis

4.1 Detailed description of short-listed tools

44) The carbon accounting tools that are short-listed for evaluation of real project datasets are described in terms of how they can be used, types of activities considered, GHG assessment boundary, carbon pools, sources, and sinks, associated GHG emissions, and other relevant criteria.

4.1.1 Carbon Benefits Project Modeling Tools

45) The CBP modeling tools were developed by CSU with several partners and were released in March 2012. The tools are applicable to any land use/management project and can be applied globally for ex ante and ex post analysis and project tracking. The system has three options:
    - The Simple Assessment (SA) is an online tool based on the IPCC method. It requires users to choose land management information from prepopulated menus and uses default IPCC factors.
    - The Detailed Assessment (DA), also an online tool, is based on the IPCC method, but it allows users to enter their own project-specific information and emission factors (EFs).
    - The Dynamic Modeling option, which is the Century Ecosystem Model linked to a GIS, has to be downloaded from the web. Expertise in GIS and ecosystem modeling is needed to use this option.

46) The SA and DA are designed to work on areas from a few hectares to approximately 10 million hectares. The Dynamic Modeling option has been used at the landscape to subnational scale but can be applied at any scale if data are available. The CBP SA and DA were specifically designed for project accounting in GEF projects. GEF projects tend to be at landscape scale, often including multiple land uses, land management systems, and smallholdings that can have a mix of livestock and cropping systems. The CBP SA and DA were also specifically designed to deal with heterogeneous situations where an overall GHG balance is required. This is achieved by allowing the user to define multiple points or polygons in the system and then describe land cover, use, and management for 'baseline' and 'project' scenarios. Furthermore, due to the landscape scope of the tools, they can also work to operate at a transboundary level, targeting projects and activities in more than one country.

47) In terms of relevance to smallholder farmer groups, the SA can be used with the sort of activity data that a land management project is likely to have and, as an online tool, only requires an Internet connection. Users choose land management options from prepopulated lists. For the DA (also an online tool), users can build their own crop/forest/grass management systems. Local datasets and measurements can be used to improve estimates,

so that costs and expertise associated with field sampling can apply, although users are encouraged to use existing local data if available (for example, from journal publications and PhD thesis). Both the SA and the DA tools are available in English, Spanish, French, Russian, Portuguese, and Chinese, with Amharic to be added.

48) The toolkit covers all ecosystems classified in the IPCC GHG Inventory Methods for AFOLU (IPCC 2006). It covers emissions of all three major GHGs (CO_2, CH_4, and N_2O) from all sources covered by the IPCC method and carbon stock changes associated with all carbon pools. Non-land-use emissions are not dealt with.

49) The output of the assessment is a spatially explicit net GHG balance expressed in CO2 equivalents. The system produces a PDF summary report and detailed Excel file reports that can be used in a GIS. Results are broken down by land use, land management, climate region, soil type, source, and sub-source categories for each geographic area that the user defines, in addition to giving a total for the entire area. Results are therefore spatially explicit, allowing multiple land use and management situations across heterogeneous landscapes to be analyzed at the same time. All results are accompanied by an estimate of uncertainty made using the IPCC error propagation method. In the DA, users can modify the model emission or carbon stock factors and adjust the uncertainty associated with their own project-specific factors.

50) The tools are focused on use in mixed landscapes where net GHG accounting is required for a range of land use and land management situations. They cover all the land use categories given by the IPCC (forests, agroforestry, trees - outside of forests, in settlements and savannas), croplands (including agroforestry integrated with croplands and perennial/woody crops, such as tree fruits and nuts), grasslands, and wetlands. Carbon stocks covered include SOC and above- and below-ground woody biomass (litter and dead wood are not covered but are in the process of being added to the tool).

51) The system can be used to address issues of leakage by defining additional 'leakage' polygons or points and adjusting the final total to account for emissions from these areas. The CBP DA has the flexibility to be used in a way that is compatible with regulatory markets and voluntary market standards. It has not yet been reviewed or directly approved by any market or standard, but there are plans to do so under the ongoing GEF project (SLM-CCMC).

4.1.2 *Agence Française de Développement* Carbon Footprint Tool

52) The AFD-CFT was developed by the AFD in 2007 and has been used since for ex ante GHG assessments of all its operations. The AFD-CFT's accounting method uses a project's or an activity's operational data to estimate its GHG emissions. A carbon footprint calculation is created by making an inventory of a project's activities. The quantities are entered into a spreadsheet that directly computes each item's emissions in CO_2 equivalents (CO_2eq) through a scientifically determined 'EF' embedded in the spreadsheet. As it

multiplies the activity's 'observable' physical data values by this EF, the spreadsheet instantly converts each physical value into its CO_{2}-eq using tons as a unit of measure. Tools can be used by any land use/management project and are freely available from the website.

53) The outputs of the assessment include emission estimates forCO_2, which results primarily from combusting fossil fuels and from producing aluminium, steel, cement, and glass; CH_4, which results from burning and/or decomposing biomass (organic material) and from producing and/or refining gasoline and natural gas; N_2O, which results from incinerating solid waste, spreading fertilizers, and/or various transportation means; hydrofluorocarbons (HFCs), which occur as a by-product of industrial processes making insulation, refrigeration and air conditioning; perfluorocarbons (PFCs), which occur as a by-product of aluminium production; and sulphur hexafluoride (SF_6), which is used for insulation and current interruption in electricity transmission and distribution equipment and electronic systems.

54) The emissions are separated into two distinct categories according to the project's phase—construction versus operation—and further sub-categories, as follows:

Project 'Construction Phase' emission sources:

- Clearing: deforestation
- Construction materials: production of cement, steel, metals, and so on
- Construction energy consumption: fuel and electricity used during construction

Project 'Operating Phase' emission sources:

- Fuel consumption: Combustion of fossil fuels.
- Electricity/heat consumption.
- Other process emissions: Includes non-energy-producing processes, especially decarbonation from cement clinker production, CH_4 released from mining and dam reservoirs, mechanization of organic waste and wastewater, N_2O released by spreading fertilizer or from industrial gases, particularly coolants.
- Purchase of goods and services: Includes the production of products consumed due to the project's activity, especially metals, plastics, glass, paper and cardboard, and chemical and agricultural products.
- Freight: Moving commodities, inputs and/or finished products by road, rail, air, or ocean.
- Passenger transport.
- Waste and wastewater.
- Land use: Changing how land is used, resulting in emissions from biomass and soil.
- Utilization: People's use of utilities and infrastructure and/or factories or other buildings. This includes the mix of their use of transportation, electricity, fuels, products, and so on, and their waste-end of life: disposing of built or produced objects.

55) The AFD-CFT calculation is compatible with the definition of ‘Scopes’ 1, 2, and 3 in the GHG Protocol:

- **Scope 1. Direct sources.** GHG emissions, from sources directly related to a project’s activity, for example, combustion
- **Scope 2. Electricity**. Indirect GHG emissions, from the generation of purchased electricity and/or heat needed for the project’s activity
- **Scope 3. Other indirect sources.** GHG emissions, from the production of materials purchased from other parties and used in the project’s activity, for example, production and/or extraction of purchased materials, waste disposal, and use of sold products and services

56) The calculation of GHG emissions resulting from a project covers the project’s entire lifetime, which is determined by the AFD-CFT. The project lifetime includes both the construction and operating phases. If building the project will generate negligible emissions, its construction phase is not included in the accounting. If the project’s construction proves emissive, by default, the AFD-CFT uses one-year durations. In the operating phase, for ease of comparison, standardized lifetimes for each type of project are suggested depending on the type of activities; the AFD-CFT user can change them on a case-by-case basis as needed and the annual GHG emissions are determined by dividing the project’s total lifetime (construction + operation) emissions by the total lifetime of the project.

57) A project’s carbon footprint calculation is presented in terms of emissions generated during the construction phase in tCO_2eq and emissions generated or abated annually during the operating phase in tCO_2eq per year. To aggregate data and compare different projects, the values for the construction and/or operating phases are added to show the average annual emissions over the project’s lifetime. No discount rate is applied to annual emissions.

4.1.3 Agriculture, Forestry, and Other Land Use Carbon Calculator (AFOLU Carb)

58) AFOLU Carb was developed by Winrock International, in collaboration with the USAID Global Climate Change team, to give USAID an easy way to mainstream its agency wide results indicator of CO_2 emission reductions and removals into its work. The tool, developed in 2007 and updated since, was designed to estimate emission reductions and removals from agriculture/forestry related USAID project activities that directly have an impact on how land is used or managed. The tool comprises six online and freely available calculators that cover forest protection, forest management, afforestation/reforestation, agroforestry, cropland management, and grazing land management. The calculators can also produce reports on above-ground forest biomass carbon, peat carbon, and soil carbon.

59) The tool uses a tiered approach (Tier 1 and 2) where data requirements are minimal, but if more detailed information is available, it allows users to override default data to produce more refined estimates. Under the Tier 1 approach, the generation of CO_2 impact estimates generally only requires that users enter the area of the activity and the geographic location

of the project activity. Under the Tier 2 approach, data input options allow users to generate more refined estimates by overriding defaults and entering project-specific information.

60) The calculators use different methods with an underlying database derived from extensive literature reviews and the IPCC 2006 Guidelines for AFOLU (IPCC 2006). In terms of application at the landscape scale, the database also houses information at the administrative level, which can vary greatly depending on the country and region you are working in.

61) An estimate of uncertainty is not provided with the output, and the developers are very clear in stating that the calculators are not designed to produce the level of accuracy needed for carbon financing. The AFOLU Carb provides a management effectiveness rating that is used as a measure of the success of project activities in terms of preventing GHG emissions or increasing removals from LUC activities, which could be used to predicate carbon leakage. The output gives the carbon change in CO_2eq per activity type, administrative unit, and project.

4.1.4 Carbon Assessment Tool for Afforestation and Reforestation

62) The CAT-AR was developed by the Tropical Agricultural Research and Higher Education Center (under Spanish acronym, Centro *Agronómico Tropical de Investigación y Enseñanza* (CATIE) in Costa Rica) for the World Bank as part of the 'Pilot Program for Assessment of GHG Intensity of Core Development Activities.' The tool consists of an Excel file and is free to download from the World Bank website.

63) The CAT-AR is a simplified version of the 'Tool for ex-ante estimation of forestry CERs', or TARAM, an Excel-based tool developed jointly by the Bio Carbon Fund (World Bank) and CATIE to facilitate the application of the approved methodologies for afforestation and reforestation CDM project activities. CAT-AR therefore closely follows the CDM approach for GHG accounting of afforestation and reforestation projects. In situations where there is a lack of project-specific data, CAT-AR can provide indicative results by applying default values (Tier 1) from the 2003 Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use, LUC and Forestry (IPCC-GPG LULUCF) and the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories (IPCC-GNGGI).

64) The CAT-AR tool considers afforestation and reforestation activities. Afforestation is defined as the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding, and/or the human-induced promotion of natural seed sources. Reforestation is defined as the direct human-induced conversion of non-forested land to forested land through planting, seeding, and/or the human-induced promotion of natural seed sources on land that was forested but that has been converted to non-forested land.

65) The GHG assessment boundary includes four components: the geographic area where the project activities take place, the time frame of the assessment, the carbon pools considered, and the sources and sinks of associated GHG.

66) With the CAT-AR tool, the GHG emissions/removals are assessed within both the discrete site(s) where the afforestation and reforestation project are located and the site(s) of the project boundary where GHG emissions/removals increase/decrease due to the project activity. The tool allows the user to monitor ex ante annual carbon stocks, changes in carbon stocks, and GHG emissions/removals up to a maximum of 30 years. It also takes four carbon pools: above-ground and below-ground trees and woody biomass, as well as above-ground and below-ground non-woody biomass. SOC and wood products are not included.

67) The tool outputs include calculations of the CO_2 removals from biomass growth, CO_2 emissions from consumption of fossil fuels (diesel or gasoline) for management purposes and from liming ($CaCO_3$ and $CaMg(CO_3)_2$), CH_4 released by burning of pre-existing trees and woody vegetation as well as non-woody vegetation for site preparation, N_2O emissions from the use of organic and synthetic fertilizers and from the burning of pre-existing trees and woody vegetation as well as non-woody vegetation for site preparation.

68) In addition to emissions/removals of GHGs, the CAT-AR considers two sources of leakage: fuel consumption out of the project boundary (transport of inputs and of staff for plantation and management, and of products) and emissions due to activity displacement outside the project boundary. The net anthropogenic GHG removals from the AR project are defined as the project net GHG removals by sinks minus the baseline net GHG removals by sinks minus the leakage. Both cumulative and yearly increments are shown in CAT-AR results.

4.1.5 Cool Farm Tool

69) The CFT was developed to be a decision support tool for farmers to help them gain a better understanding of the sources and sinks of agricultural GHGs in their production practices. The main emphasis of the tool is on arable land, although livestock and woody perennial crops are included. The intended users of the tool are multinational or national food and beverage companies, farmers, cooperatives, and development and other organizations that work with farmers. The tool was developed by Unilever, the University of Aberdeen, and the Sustainable Food Laboratory. The first version was released in early 2010, with subsequent versions released in early 2011 and a new version in May 2012. The tool is Excel based and uses standardized software available in most countries with an accompanying online questionnaire available in English and Spanish. The tool itself is available only in English, although there are plans to make it available in more languages, starting with Spanish.

70) The tool has global applicability because it uses equations, either based on modifications of the IPCC approach or on other sources in the literature (Hillier et al. 2011). It comprises

many sub-models dealing with arable crops, woody perennial crops, livestock and LUC to or from grassland, arable land, and forest. GHG emissions include CO_2, CH_4, and N_2O resulting from soil disturbance, fertilizer use, resident nitrogen, crop residue management, pesticide use, livestock production, and LUC. Additionally, the tool covers carbon stock changes in soil and biomass resulting from management changes. Emissions from on-site electricity use, fertilizer and pesticide production, and transport (for inputs and of the final product) are also included. The output of net GHG emissions is calculated in CO_2eq in tables, graphs, and charts, broken down by emissions sources and sinks.

71) The output is not spatially explicit, as it is for individual agricultural products. The tool does not assess uncertainty and the authors state that the tool is not intended as a carbon market access mechanism, but it can provide a screen for carbon market opportunities because it can be used to run 'what if' scenarios.

72) Leakage and permanence is only addressed in relation to above-ground tree and non-tree biomass. Although the tool was originally designed to be used for individual products, it can be used at other scales if the details of all the products produced on those scales are known.

73) There are plans to develop a web-based version of the tool to improve the transparency, scalability, user guidance, and user interface. There are also plans to enable integration of CFT into other supply chain GHG and life cycle analysis (LCA) resources used by private companies, commercial service providers, and public interest organizations. The CFT was recently accepted by the GHG metric working group for the Stewardship Index for Specialty Crops and will be recommended to the Coordinating Council.

4.1.6 Climate Change, Agriculture, and Food Security Mitigation Options Tool (CCAFS-MOT)

74) The CCAFS-MOT was developed by the University of Aberdeen and the CGIAR Research Program on CCAFS, with support from USAID and the U.S. Department of Agriculture, to provide fast and accessible information on mitigation options for agriculture. The tool suggests mitigation options that are well suited to the production system, soils, and climatic conditions of the farm. The suggestions are based on empirical models and data from over a dozen different research studies.

75) As an Excel-based tool, the CCAFS-MOT brings together several empirical models to estimate GHG emissions in rice, cropland, and livestock systems and to provide information about the most effective mitigation options. The tool allows for management-relevant GHG assessments to be made with relatively little effort and the estimation of GHG emissions from various crops (for example, barley, maize, and sugarcane), crop groups (for example, vegetables and legumes), and livestock production in different regions.

76) The tool is intended as a decision-support tool for policy advisers and extension services around the world and is widely contextualized, promoted, and disseminated, enabling national decision makers to prioritize low-emission initiatives. The outputs of the tool are

estimates of emissions in terms of total GHG emitted in kilograms of CO_2equivalent per hectare (kg CO_2eq per ha) and in terms of GHG intensity, that is, kg of CO_2 equivalent per unit of product (kg CO_2eq per unit). Users choose management practices. The aim of the tool is to accommodate a range of users from an introductory to an advanced level, depending on objectives and issues such as time, existing knowledge, or data available.

77) Leakage and permanence are not addressed. The tool calculates the GHG emissions (emissions per hectare and per yield) due to current management practices and provides a ranked list of different management options to reduce emissions. The options are ranked by emissions estimates (total GHGs emitted in kilograms of CO_2eq[12] per hectare and in terms of GHG emissions intensity), which helps compare the potential impact of each option.

4.1.7 Ex-Ante Carbon-Balance Tool

78) EX-ACT was developed by the FAO to provide anyone developing agriculture and forestry projects (more particularly, program officers, funding agencies, and ministries) with a tool to estimate the impact of projects on GHG emissions and carbon sequestration (Bernoux et al. 2010). The tool consists of an Excel file and is free to download from the FAO website.

79) The tool was developed using the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) in conjunction with other methodologies and reviews of default coefficients (Lal 2006; Smith et al. 2008). This makes the tool globally applicable. It assesses the impact of agriculture and forestry activities on carbon stock changes per unit of land and CH_4 and N_2O emissions in tCO_2eq per hectare per year. The tool covers all GHG emissions linked with LULUCF activities covered by the 2006 IPCC Guidelines (IPCC 2006) plus some additional sources.

80) EX-ACT is applicable to development projects in the areas of crop management, SLM, agroforestry, grassland restoration, production intensification, and livestock management. The tool covers the following sources and activities:
- Deforestation/afforestation/reforestation
- Annual and perennial cropland management
- Flooded rice management practices
- Livestock and dairy (enteric CH_4 and CH_4 from manure)
- Nutrient management (liming, fertilizers, pesticides, and herbicides)
- Energy consumption inputs and farm machinery (electricity and fuel)

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[12] CO_2 equivalent: It is a quantity to express the relative impact on the radiative forcing, that is, on the global warming, of a substance (mostly GHGs) compared to that of CO_2 and is calculated using the Global Warming Potentials (GWPs). GWPs are measurements of the relative radiative effect of a given substance compared to that of CO_2, over a specific period. For instance, the official values for CDM of CH_4) are set to 21 (meaning that 1 kg of CH_4 is as effective, in terms of radiative forcing, as 21 kg of CO_2) and to 310 for N_2O, based on a secular time scale.

81) Furthermore, the tool covers emissions associated with carbon stock changes during land use conversion; biomass or residue burning; flooded rice cultivation; organic soils; livestock production; and inputs of lime, fertilizer, and manure. The tool also provides comprehensive coverage of non-land-use emissions associated with agriculture, such as those from the production, transport, storage, and transfer of agricultural chemicals and emissions from energy use and infrastructure (electricity and fuel consumption associated with buildings and irrigation system construction and maintenance).

82) The output is not spatially explicit, but it provides a carbon balance resulting from project activities (for example, what would happen above a baseline scenario). This is accompanied by a rough estimate of uncertainty (rounded up to the nearest 10 percent), which is calculated using the method given in the IPCC 2006 Guidance (IPCC 2006).

83) Issues of leakage are not addressed specifically, but they could be addressed by adjusting input information. Permanence is not addressed, but the uncertainty results could be used to highlight categories where problems of permanence might arise. No analysis of social or economic impacts is included, although the tool output has been used to feed into an economic analysis using the Marginal Abatement Cost Curves (Bockel et al. 2012). Tier 1 EFs are supplied, with the option for users to input their own data. Overall, the tool requires a fair amount of detailed information.

4.2 Detailed characterization of the short-listed tools

84) This section focuses on the ability of the seven short-listed tools to perform specific tasks, including (a) assessment of GHG consequences of SLM projects, (b) consideration of IPCC methods, (c) accounting for climate and soil in GHG evaluation, (d) GHG scope, and (e) treatment of uncertainties. This detailed characterization should help users understand and interpret the possible response while running the tools on real datasets from GEF and other SLM projects.

4.2.1 Assessing GHG consequences of projects

85) The availability of approved carbon assessment methodologies is crucial for carbon crediting. These methodologies are the blueprints used to design, verify, and operate carbon projects. They document the protocol for quantifying carbon emissions and removals and include guidelines for identifying baseline scenario and assessing additionality in all carbon pools relevant to the project.

86) Carbon calculators for project evaluation can be split into two subcategories—carbon market-oriented and non-carbon market-oriented tools—each one tailored for a different type of projects. For example, carbon market-oriented tools assume that a project is being run primarily for carbon mitigation benefits or with a heavy mitigation focus, whereas non-carbon market-oriented tools are often aimed at projects that have a primary focus on carbon co-benefits associated with the planned activities. The carbon calculators should

account for all possible mitigation options, including carbon storage. The type of calculators determines the level of expertise expected to use the tool.

87) Tools focusing on carbon crediting schemes have been applied in countries where agriculture is subjected to carbon credits or with potential CDM projects. Tools not focusing on carbon crediting schemes usually account for all possible mitigation options, especially carbon storage. These tools aim to provide information for project managers, stakeholders, and donors.

88) Table 7 indicates that, of the short-listed tools, only one is specifically designed for carbon crediting (the CAT-AR). Despite this, there may be opportunities for further developing some of the tools to meet the requirements for voluntary or other carbon markets, through the integration of specific carbon assessment methodologies.

Table 7: Selected tools and carbon credit

No.	Tool	Focus on Carbon Credit	Not focused on Carbon Credit
1	AFD-CFT		x
2	AFOLU Carb		x
3	CAT-AR	x	
4	CBP		x
5	CCAFS-MOT		x
6	CFT		x
7	EX-ACT		x

4.2.2 Intergovernmental Panel on Climate Change methods

89) The IPCC oversees the review and compilation of all studies on climate change and has published guidelines and good practice references for GHG accounting (IPCC 2006). These guidelines are referenced in all the short-listed GHG accounting tools. GHG accounting using the IPCC methodology can be carried out at three levels:

- Tier 1 corresponds to accounting for large areas, with average EFs provided for large ecoregions of the world.
- Tier 2 is similar but uses state- or region-specific data, with more accurate EFs and carbon stock changes when available.
- Tier 3 is very detailed, applying biophysical models of GHG processes that were developed at the country or regional level and which are different from those recommended by the IPCC, but which have been demonstrated to improve predictions of GHG emission assessments.

90) For emissions of CO_2 from energy consumption and all nitrous oxide (N_2O) and methane (CH_4) emissions, the generic approach considers multiplying an activity data (which can be land area, animal numbers, mass unit, or fuel quantity) by its specific EF for each source. For non-energy-related CO_2 emissions or removals, most calculations, except otherwise specified, use an approach with a stock difference method. The stock difference method

calculates emissions or removals as the change over time of carbon stocks for the different pools.

91) The IPCC methods are based on five carbon pools—above-ground biomass, below-ground biomass, litter, deadwood, and soil carbon. Six out of the seven tools account for above-ground and soil carbon, but the CCAFS-MOT and CFT tools do not account for below-ground, litter, and deadwood. The CBP, AFD-CFT, and AFOLU Carbon Calculator (AFOLU Carb) do not account for litter and deadwood. EX-ACT is the only tool accounting for all five carbon pools.

Table 8: Tools comparison based on the IPCC GHG accounting approaches and carbon pools

No.	Tool	IPCC Tier used (1, 2)	Gain-loss and stock difference methods	Above-ground	Below-ground	Litter	Dead wood	SOC
1	AFD-CFT	x	X	x	x			x
2	AFOLU Carb	x		x	x			x
3	CAT-AR	x	X	x	x			
4	CBP	x	X	x	x			x
5	CCAFS-MOT	x		x				x
6	CFT	x		x				x
7	EX-ACT	x	X	x	x	x	x	x

4.2.3 Accounting for climate and soil

92) In many SLM activities, emissions depend on the local environment, especially soil and climate conditions. These parameters have an especially strong impact on N_2O emissions (nitrification-denitrification processes) and carbon storage potential. The potential carbon sequestration is controlled primarily by pedological factors that set the physicochemical maximum limit to storage of carbon in the soil. Such factors include soil texture and clay mineralogy, depth, bulk density, aeration, and proportion of coarse fragments.

93) The attainable carbon sequestration is set by factors that limit the input of carbon to the soil system. The net primary production (NPP)—the rate of photosynthesis minus autotrophic respiration—is the major factor influencing the attainable sequestration and is modified by above-ground versus below-ground carbon allocation. Land management practices that increase carbon input through increased NPP tend to increase the attainable level of carbon sequestration. Adequately accounting for soil emissions is therefore crucial. For instance, soil N_2O accounts for some 40 percent of agricultural emissions at the global level, and soil carbon storage/destocking is the highest carbon sink potential with the ability to store or release the equivalent of several years of global emissions (Baumert, Herzog, and Pershing 2005). Soil carbon turnover varies from a few weeks to several thousand years depending on the carbon pool.

94) Climate has both direct and indirect effects on attainable sequestration. The decomposition rate of organic matter increases with temperature but decreases with increasingly anaerobic conditions. The actual carbon sequestration is determined by land management factors that

reduce carbon storage such as erosion, tillage, residue removal, and drainage. Theoretically, the potential soil carbon sequestration capacity is equivalent to the cumulative historical carbon loss. Despite this, only 50 percent to 66 percent of this capacity is attainable through the adoption of SLM practices.

95) At the regional and local scales, the climate is usually quite homogenous. Special care is needed, however, when working on islands or mountainous territories where sub-regional climates can differ significantly within short distances. On the other hand, management practices can have a strong impact on microclimates, affecting their biophysical processes involved in GHG emissions, including volatilization. Emissions factors and GHG tools do not usually have sufficient accuracy to consider the impact of microclimates on soils emissions.

96) Soil heterogeneity can also be very high, especially concerning carbon content, which is strongly affected by cropping management practices. Thus, for limiting uncertainties from soil emissions, the field scale approach seems more appropriate than farm scale or regional scale. To consider soil and climate parameters on emissions, three options are possible:
- User-defined data
- Use of national/regional averages
- Use of the geographic information system (GIS) approach

97) The most accurate data are obtained through the description of soil and climate using key parameters such as temperature, rainfall, carbon content, bulk density, and texture. These data should be obtained from multiple samplings to reduce uncertainty, with minimum sample size provided by literature depending on the parameter required (Post et al. 2001).

4.2.4 GHG scope

98) This review indicates the lack of homogeneity among the tools in terms of the GHG accounting scope. Indeed, different tools account for different sources (for example, some include energy, some infrastructure and transport, some N-fixing plant emissions, some soil carbon dynamics, and so on) and all are designed for different purposes and are context-specific. This lack of homogeneity markedly impedes direct comparison of results from different calculators. For a better interpretation of results, users need to apply standardization based on average emission per hectare for cereal crops or livestock that is seldom provided by guides to users.

99) Only five out of the seven short-listed tools collectively account for CO_2, N_2O, and CH_4. The AFD-CFT and AFOLU Carb do not account for N_2O. Additionally, the AFOLU Carb does not account for CH_4 (see Table 9). The differences in scope can strongly affect the results of cross-comparison of tools, especially if some calculators account for carbon soil sequestration and others do not. However, in most situations, GHG tools account for hotspots of GHG emissions and variation in scope have a rather limited impact on the

results as indicated by studies comparing several GHG calculators under similar circumstances (Soil Association Producer Support; FAO 2010). The Life Cycle Assessment studies indicate that the agricultural production stage represents the major stage for GHG emissions in the product life cycle of most foods (Roy et al. 2009; Virtanen et al. 2010; Weber and Matthews 2008); therefore, transport (if not by air), processing, and packaging (except for glass and tins) are not hotspots of GHG emissions in food production.

Table 9: Sources, sinks, and SLM activities accounted for by each tool

No.	Tool	GHG			Analysis type		SLM activities										
		CO_2	N_2O	CH_4	Ex ante	Ex post	Cropland	Horticulture	Rangeland/grazing land	Grassland	Agroforestry	Forest	Land use management (afforestation/deforestation)	Forest management	LUC	Investment and inputs	Livestock
1	AFD-CFT	x	no	x	x	x	Limited	x	x	x	x	no	x	no	x	x	no
2	AFOLU Carb	x	no	no	x	no	no	no	x	no	x	no	no	Limited	no	no	no
3	CAT-AR	x	x	x	x	x	no	no	no	no	no	no	Limited	no	x	x	no
4	CBP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5	CCAFS-MOT	x	x	x	x	no	x	x	x	x	no	no	no	no	x	no	x
6	CFT	x	x	x	x	no	x	x	no	no	no	no	no	no	no	no	x
7	EX-ACT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x means the tool meets the criteria, Limited means it partially does meet the criteria, while no means it does not.
x means the tool meets the criterion, Limited means it partially does meet the criterion, while no means it does not.

4.2.5 Uncertainties

100) Global uncertainty in GHG assessment results from three sources: uncertainties in activity data (inventory), uncertainty due to year-to-year variability in climate and management factors, and uncertainty in EFs (characterization) (Gibbons, Ramsden, and Blake 2006). Uncertainties can be very high for the agricultural sector, depending on the emission process considered. Some tools account for uncertainties, while others do not. Table 10 indicates that only CBP and EX-ACT quantify uncertainties in their GHG evaluation. Five out of the seven tools account for leakage, the CFT tool at least partially.

101) At the farm scale, uncertainty can be caused by the inventory as data tends to be directly provided by farmers. At the landscape or regional scale, data are based on statistical average or expert knowledge, introducing large uncertainties. Because GHG tools do not assess inventory uncertainties, users should be aware of them and factor them into decision

making. However, evaluating the impact of these uncertainties is often quite difficult. One way to reduce them is to go through an iterative process that ensures high accuracy for activities with a strong impact on the outcome, such as the number of cattle or the quantity of nitrogen fertilizers.

102) Year-to-year uncertainty can be reduced using average climatic data and management practices over several years. Intra annual climate variability interfering with management practices also induces uncertainties, but as GHG tools provide results per year, there is virtually no way of addressing this. For example, due to different climatic conditions, for the same amount of nitrogen, nitrification-denitrification rates may be higher in some years than others. Only biophysical models with daily or monthly pace could account for such detailed differences. Moving from Tier 1 to Tier 3 IPCC approach reduces these uncertainties.

103) In interpreting results, the high level of uncertainty occurring in agriculture and forestry activities should be mentioned, especially when comparing two projects or two areas. Information on the causes of the uncertainties can be very important. The acceptable level of uncertainty depends on the data being considered and the goal of the GHG assessment. At the landscape level, information is generally more generic than at the farm level; thus, a higher uncertainty level is acceptable.

Table 10: Uncertainty and leakage accounting in the carbon accounting tools

No.	Tool	No value for uncertainty	Quantitative value of uncertainty provided	Leakage
1	AFD-CFT	x		x
2	AFOLU Carb	x		x
3	CAT-AR	x		
4	CBP		x	x
5	CCAFS-MOT	x		
6	CFT	x		Partially
7	EX-ACT		x	x

4.2.6 Presentation of GHG assessment results and shortlisted tools

104) The results are expressed in different units. They can be expressed in ton CO_2 equivalent, such as tCO_2eq per year, tCO_2eq per project (several years), tCO_2eq per ha per year, and tCO_2eq per kg of products. The results might also be expressed in net value (emission – storage) or provide both values. Users must be careful to distinguish between tons of carbon and tons of CO_2 (1 ton of CO_2 is 3.67 times a ton of carbon). Some calculators provide results only for one situation, while others provide the value for the baseline scenario (also known as a business-as-usual scenario) and with-project situation (project scenario).

Table 11: Results types provided by the carbon accounting tools

No.	Tool	GHG/ha	GHG/product ex: GHG/ kg grain)	GHG/project with comparison between several scenarios	Other results (only GHG for full farm/territory)
1	AFD-CFT	x		x	
2	AFOLU Carb	x			x
3	CAT-AR	x			
4	CBP	x		x	x
5	CCAFS-MOT	x	x		x
6	CFT	x	x		x
7	EX-ACT	x	x	x	

4.2.7 Overall comments and conclusion

105) Except for the CAT-AR tool, the tested GHG accounting tools are not specifically designed for a carbon market. All the tools follow the IPCC and stock difference methods. The carbon pools considered within each calculator vary; however, all short-listed calculators account for above-ground and SOC. Only the EX-ACT tool accounts for all the five carbon pools.

106) All calculators account for soil and climate differences and for the main GHG sources and emissions and can identify hotspots (except emissions from LUC that are often ignored). As for the GHG coverage, only five out of the seven short-listed tools account for CO_2, N_2O, and CH_4 collectively. Five out of the seven tools account for leakage, one of them at least partially. Only CBP and EX-ACT quantify uncertainties in their GHG evaluation.

107) While interpreting the results, it is necessary to consider the different objectives of each tool as they reflect the different areas of focus, methodologies, GHG scope, uncertainties along the analysis, and leakage. Each tool is characterized by certain competitive advantages and is often the first methodological choice regarding its own field of specialization. These differences concerning methodologies and scope have a significant impact on results. The main challenges with landscape assessments is how to consider the heterogeneity of production systems analyzed and the uncertainty of biological processes involved in GHG emissions. Therefore, it is impossible to do a straight comparison between the tools. Detailed analyses would be needed to evaluate precisely the variability of results from the tools. Ultimately the choice of tool will depend on the specific needs of the user.

108) It is recommended that the user pays attention to the GHG scope accounted for and the uncertainties associated with results if major differences are observed when interpreting results obtained from the application of various calculators to GEF development projects.

5. Application of the Short-Listed Tools to GEF Development Projects

109) Climate change will have a major impact on agricultural production, comparative advantages, and trade flows. A greater divergence between regions in terms of agricultural output is likely. For the most part, countries in the tropics and subtropical zones, mostly developing economies, are expected to lose in terms of agricultural production whereas countries in temperate zones, mostly developed economies, are expected to gain. In the absence of adoption of sustainable agricultural intensification and other climate-smart agricultural practices, these regional differences could have huge implications on GHG emissions.

110) This report is intended to help potential users select the most appropriate tool for an SLM project's GHG assessment. Comparing the use of the short-listed GHG assessment tools to assess the GHG footprint of SLM operations entails mapping the tools within the wide range of potential carbon sequestration and GHG emission reduction activities. So far, the short-listed tools have been used for a range of operations worldwide and by various partner organizations, including the World Bank, FAO, and AFD.

111) The testing of the tools goes beyond a desk analysis and includes running the tools on real datasets from GEF projects. Eighteen SLM projects (Table 12) were identified and analyzed using the seven short-listed tools. Two projects were subject to field data collection and are used as case studies for an in-depth assessment of each tool. The selected projects represent the implementation of land use systems and management practices across a wide spectrum of SLM technologies, with the aim of improving plant management and rainwater management and reducing risks to production systems, people, and assets. Based on the tools' scope and the IPCC GHG accounting approaches, 51 activities were assessed and eight main SLM activities were identified (Table 13). The full results of the assessment are provided within annex 1.

112) The study includes 16 countries (Belarus, Brazil, Burkina Faso, Burundi, Chile, China, Costa Rica, Ethiopia, Guinea, Jordan, Mali, Moldova, Morocco, Serbia, Tunisia, and Turkey), representing five regions (Africa, Middle East and North Africa, Latin America and the Caribbean, Eastern Europe and Central Asia, and Europe). Many of these countries are highly dependent on the production and exports of agricultural goods and they are facing a range of climate change-related challenges.

Table 12: List of projects selected for the study

No.	Project ID	Country	Region	Project name	GEF ID
1	P147760	Belarus	ECA	Forestry Development Project	6947
2	P086341	Brazil	LCR	BR GEF Rio Grande do Sul Biodiversity	2450
3	P070867	Brazil	LCR	Caatinga Conservation and Management – Mata Branca – (GEF)	2450

No.	Project ID	Country	Region	Project name	GEF ID
4	P130568	Burkina Faso	AFR	Sustainable Land and Forestry Management Project	5187
5	P127258	Burundi	AFR	Sustainable Coffee Landscape Project	4631
6	P087318	China	EAP	Guangxi Integrated Forestry Development and Conservation Project	2634
7	P090376	China	EAP	GEF Shanghai Agricultural and Non-point Pollution Reduction	3223
8	P061315	Costa Rica	LCR	Sustainable Cacao Production in Southeastern Costa Rica (GEF-MSP)	979
9	P090789	Ethiopia	AFR	ET Sustainable Land Management (ECPSLM)	4630
10	P081297	Guinea	AFR	Community-based Land Management Project	1877
11	P075534	Jordan	MNA	Integrated Ecosystem Management in the Jordan Rift Valley GEF	1214
12	P129516	Mali	AFR	Natural Resources Management in a Changing Climate in Mali	5270
13	P118518	Moldova	ECA	Moldova Agriculture Competitiveness Project	4630
14	P129774	Morocco	MNA	Morocco Social and Integrated Agriculture	5292
15	P635621	Serbia	EUR	Contribution of Sustainable Forest Management to a Low Emission and Resilient Development	9089
16	P613134	Turkey	ECA	Sustainable Land Management and Climate-Friendly Agriculture Project	4583
17	P085621	Chile	ECA	Sustainable Land Management Project	4140
18	P112568	Tunisia	MNA	Second Natural Resources Management Project	3669

Table 13: Definition of activity-categories considered in line with IPCC's and FAO's definitions

Activities	Definition
Afforestation/reforestation	Refers to the artificial establishment of forest on lands that previously did not carry forest within living memory, while reforestation is defined as the artificial establishment and natural regeneration of forest on lands that carried forest before.
Deforestation	Refers to the change of land cover with depletion of tree crown cover to less than 10 percent. Changes within the forest class (for example, from closed to open forest) that negatively affect the stand or site—and, in particular, lower the production capacity—are termed forest degradation.
Forest management	Refers to the reductions in the productive capacity of the forest. For each activity, the initial state of the forest and its expected final states (without project and with project) were identified. It includes directly human-induced change (for example, as a result of improved silviculture), indirect influences (for example, nitrogen or CO2 fertilization), and natural causes (including natural successional processes). Within this study two main categories of forest management were identified: forest fire management and forest management and degradation (biomass loss).
Annual cropland	Refers to lands covered with temporary broadleaf or grass-type crops that are harvested at the completion of the growing season, then remain idle until replanted. Two categories were identified for annual crops: newly implemented systems after land conversion of other land use systems and annual systems that remain annual systems.
Perennial cropland	Refers to lands covered with temporary broadleaf or grass-type crops that are harvested at the completion of the growing season, then remain idle until replanted. Two categories were identified for perennial crops: newly implemented systems after land conversion of other land use systems and perennial systems that remain perennial systems.
Grassland management	Refers to lands with herbaceous types of cover, typically graminoids. Tree and shrub cover is less than 10 percent. Two categories were identified for grassland systems: newly implemented systems after land conversion of other land use systems and grassland systems that remain grassland systems.

Activities	Definition
Livestock	Refers in a broad sense all grown animals regardless of age, location or purpose of breeding. Six main categories of livestock are fixed: dairy cattle, other cattle, buffalo, sheep, swine (market), swine (breeding), goats, camels, horses, mules, asses, poultry, deer, and alpacas.
Inputs	Refers to the use of agricultural chemicals, N fertilizer in non-upland rice systems (that is, flooded rice systems), sewage, and organic fertilizers in farm operations and based on projects activities.
Investments	Refer to electricity consumption, fuel consumption, installation of irrigation systems, and building of infrastructure.

Desk study analysis

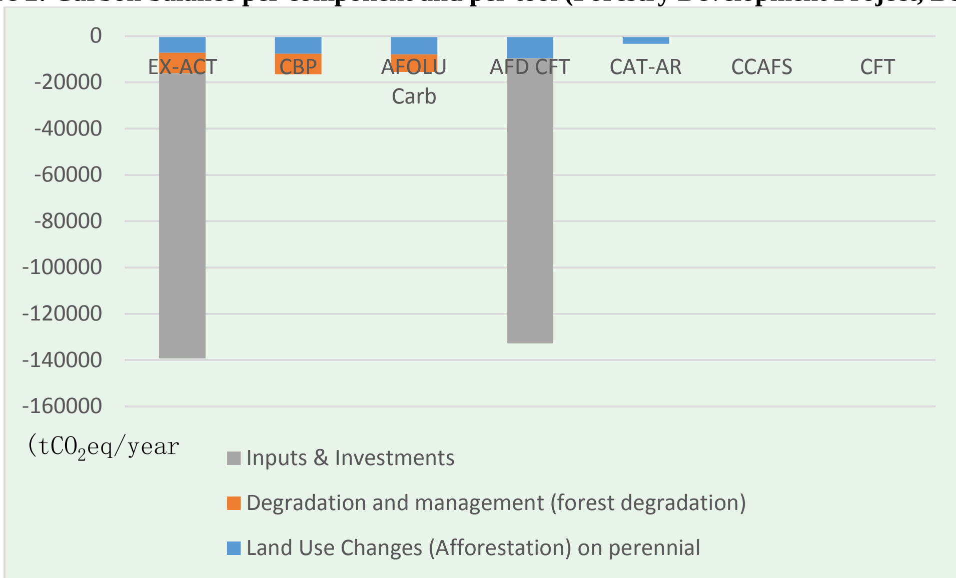
5.1 Belarus-Forestry Development Project (FDP)

113) The development objective of the project is to enhance the sustainable management of forestry assets in targeted project areas, through increasing silvicultural thinning and improving afforestation and reforestation capacity, thereby providing enhanced employment opportunities while continuing to provide global public goods. The project has three components:

- Component 1: Improvement of silviculture and the sustainability of forest management
- Component 2: Improvement of forest fire prevention, monitoring, detection, and suppression
- Component 3: Capacity building for sustainable forest management

114) Based on the scope and applicability of the tools, the activities under Components 1 and 2 of the project were assessed. The results of the carbon balance obtained by the tools (see annex 1) are summarized in Figure 2. The analyses comprise the improvement of forest nurseries for afforestation and reforestation, the use of woody biomass from logging residues from final and selective fillings, and the improvement of forest fire management**.**

Figure 2: Carbon balance per component and per tool (Forestry Development Project, Belarus)



115) The analysis considers the following set of information, determined as the minimum information required to carry out a GHG analysis:

- Country/continental region: Belarus/Eastern Europe
- Climate and moisture regime: Cool temperate moist
- Dominant regional soil type: Sandy soils
- Duration of the project implementation: 5 years and duration of analysis (also referred to as accounting period) set to 20 years[13]

116) While some calculations might not require all the above information, they might also require information on the moisture regime and the Mean Annual Temperature (MAT) of the project area.

5.1.1 Detailed project analysis per activity for the Belarus Forestry Development Project

5.1.1.1 Afforestation/reforestation (initial land use: perennial cropland)

117) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP Simple Assessment [SA], AFD-CFT, AFOLU Carb, and CAT-AR) were appropriate for analyzing the afforestation activities (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −6,727.6 tCO_2eq per year and 1,890.8 tCO_2eq per year, and the 95 percent confidence interval of the mean is estimated at between −5,070 and −8,384 tCO_2eq per year.

[13] The accounting period is defined within as the sum of the implementation phase and the capitalization phase. These values are set at minimum 20 years used either in IPCC 1996 or 2006 Guidelines and are gathered from a large compilation of observations and long-term monitoring.

118) Except for the CAT tool, all the results generated by the tools were situated within this estimated range. The analysis suggests that even if the project is not implemented, some forest plantation would be developed (baseline scenario). However, the CAT tool only considers afforestation with project implementation. Thus, the estimated carbon balance using CCAFS-MOT and CFT was calculated separately (with- and without- project scenarios) for the sake of comparison. In addition, the CAT tool considers cropland and grassland as baselines for land use activities.

119) The tools with GHG balance within the estimated range of results are the EX-ACT tool, CBP SA, AFOLU Carb, and AFD-CFT. The AFOLU Carb estimates a carbon balance value further away from the mean value. This could be explained by the fact that the AFOLU Carb is not based on the gain-loss and stock difference methods, and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools (Table 8). The differences between the EX-ACT, CBP SA, and AFD-CFT tools are minor: EX-ACT and CBP SA have a 5.34 percent difference, EX-ACT and AFD-CFT a 4.19 percent difference, and CBP SA and AFD-CFT a 1.15 percent difference.

120) Based on this analysis, the three tools, EX-ACT, CBP, and AFD-CFT, are suitable for afforestation GHG analysis when considering perennial cropland as the initial land use (ILU) and when afforestation activities are carried out with and without the project implementation.

5.1.1.2 Forest management and degradation (forest fire management)

121) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFOLU Carb) were used to analyze forest management and degradation activities (see Table 9). Because the activities analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used.

122) The difference between the results obtained from EX-ACT and CBP SA was small. Although the AFOLU Carb tool considers the fire impact, the difference in results is explained by the suggested default Forest Carbon Stock value, which is the average of the above- and below-ground forest carbon stock in the tree pool (Table 8). The difference in results between the EX-ACT, AFOLU Carb, and CBP SA tools are minor: EX-ACT and CBP have a 1.36 percent difference, EX-ACT and AFOLU Carb a 1.4 percent difference, and CBP and AFOLU Carb a 1.5 percent difference. This difference could be explained by the fact the CBP SA does not consider fire occurrence lower than 1 percent, and the activity suggests that the fire impact (percent burnt) will be reduced from 0.2 percent without the project implementation to 0.1 percent yearly with the project implementation. Based on this analysis, the three tools—EX-ACT, CBP, and AFOLU Carb—are suitable for GHG analysis of forest fire management.

5.1.1.2.1 Inputs and investments (electricity, gasoil, wood consumption, and irrigation)

123) Based on the sources, sinks, and SLM considered by the tools, only EX-ACT and AFD-CFT were used to analyze energy consumption (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. A minimal difference was observed among the results, owing to the similarities in the EFs used by the tools. The AFD-CFT, however, does not account for GHG emissions caused by irrigation infrastructures.

124) Based on this analysis, the two tools—EX-ACT and AFD-CFT—are suitable for the GHG analysis of electricity, fuel consumption, and wood consumption, while EX-ACT also estimates emissions related to irrigation systems.

5.1.2 Project carbon balance

125) Based on the sources, sinks, and SLM activities, the EX-ACT is the only tool capable of assessing the full range of GHG consequences associated with the Belarus Forest Development Project. The estimated carbon balance is −2,786,149 tCO_2eq for the entire duration of the analysis (20 years) or −0.2 tCO_2eq per hectare per year.

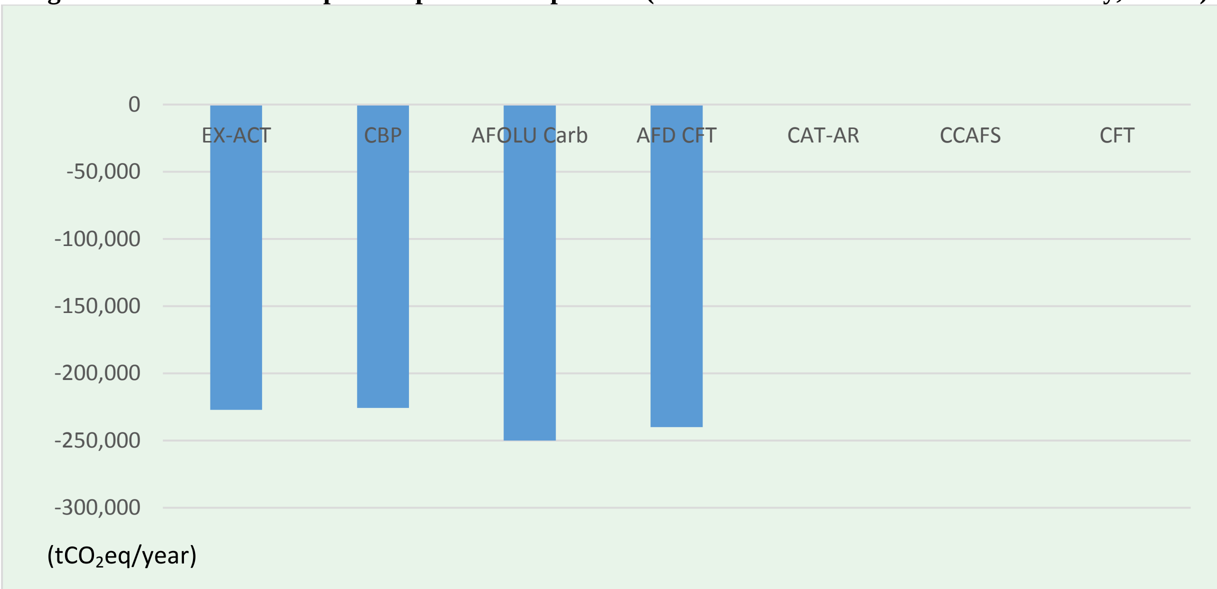
5.2 Brazil, GEF Rio Grande do Sul Biodiversity

126) The project development objective is to promote the conservation and restoration of biodiversity in the grassland ecosystem in the Rio Grande do Sul's territory by mainstreaming biodiversity conservation within forestry, agriculture, and livestock productive landscapes. The project has three components:

- Component 1: On-Farm Biodiversity Mainstreaming
- Component 2: Biodiversity Management
- Component 3: Project Management

127) Based on the scope and applicability of the tools, the activities of Component 1 were assessed. The results of the carbon balance obtained are summarized in Figure 3. The analyses focus on the rationalization of land conversion processes by promoting the adoption of biodiversity conservation practices in the main productive systems of the grasslands. As a result, moderately degraded grassland is brought under enhanced biodiversity conservation.

Figure 3: Carbon balance per component and per tool (BR GEF Rio Grande do Sul Biodiversity, Brazil)



128) The analysis considers the following set of information, determined as the minimum information required to carry out a GHG analysis:

- Country/continental region: Brazil/South America
- Climate and moisture regime: Tropical wet
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

129) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.2.1 Detailed project analysis per activity for the Brazil GEF Rio Grande do Sul Biodiversity Project

5.2.1.1 Grassland management

130) Based on the sources, sinks, and SLM activities considered by the tools, four tools (EX-ACT, AFOLU Carb, CBP SA, and AFD-CFT) were used to analyze grassland management activities (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −235,641 tCO_2eq per year and 11,509.8 tCO_2eq per year. The 95 percent confidence interval of the mean is between −224,361 and −246,920 tCO_2eq per year.

131) All the results generated by the tools are situated within this estimated range. Minimal differences were observed within the results. These differences were mainly due to the use

of different IPCC GHG accounting approaches and carbon pools (Table 8), and uncertainties associated with the Tier 1 methodology. For example, the AFD-CFT tool calculates the default soil carbon stock changes based on a set of IPCC questions, whereas the AFOLU Carb provides estimated values for relative stock change factors.

132) The differences in results between the tools varies: EX-ACT and CBP have a 0.62 percent difference, EX-ACT and AFD-CFT a 5.55 percent difference, EX-ACT and AFOLU Carb a 33 percent difference, CBP and AFD-CFT a 28 percent difference, CBP and AFOLU Carb a 32 percent difference, and AFD-CFT and AFOLU Carb a 4 percent difference.

5.2.2 Project carbon balance

133) The total estimated carbon balance for the Brazil, BR GEF Rio Grande do Sul Biodiversity Project ranges between −1.06 and −1.17 tCO_2 per hectare per year.

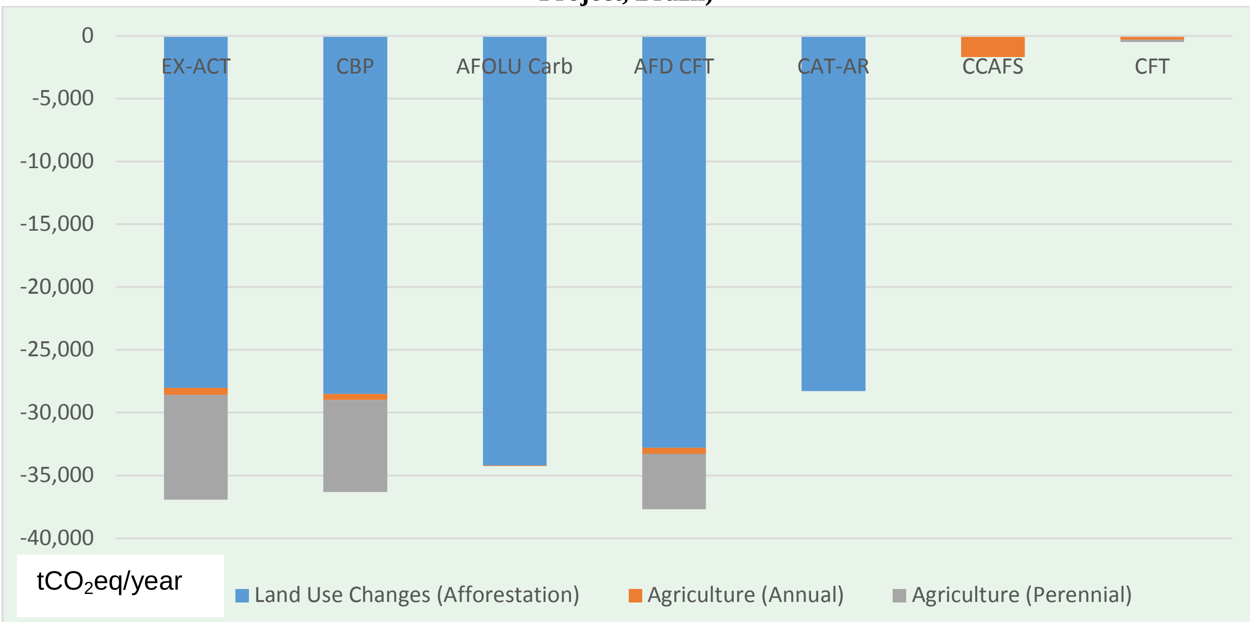
5.3 Brazil, Caatinga Conservation and Sustainable Management Project

134) The project's global environmental objective and its development objective are the same: contributing to the preservation, conservation, and sustainable management of the biodiversity of the Caatinga in the states of Bahia and Ceara, while improving the quality of life of its inhabitants, through the introduction of sustainable development practices. The project has two components:

- Component 1: Institutional and Policy Support for Integrated Ecosystem Management
- Component 2: Promotion of Integrated Ecosystem Management Practices

135) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 4. The analyses focus on (a) promoting Integrated Ecosystem Management Practices, (b) supporting the implementation of cost-effective and replicable Integrated Ecosystem Management practices at the local level to ensure sustainability of conservation efforts, and (c) preventing land degradation in the Caatinga Biome.

Figure 4: Carbon balance per component and per tool (Caatinga Conservation and Sustainable Management Project, Brazil)



136) The analysis considers the following set of information, determined as the minimum information required to carry out a GHG analysis:

- Country/continental region: Brazil/South America
- Climate and moisture regime: Tropical wet
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

137) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.3.1 Detailed project analysis per activity for the Brazil Caatinga Conservation and Sustainable Management Project

5.3.1.1 Afforestation/reforestation (ILU: grassland)

138) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP SA, AFD-CFT, AFOLU Carb, and CAT-AR) were used to analyze afforestation activities (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −32,363.2 tCO_2eq per year and 6,374.8 tCO_2eq per year, with 95 percent confidence interval of the mean between −26,775 and −37,951 tCO_2eq per year.

139) The project information suggests that afforestation activities would take place on grassland (initial land use [ILU]). All the results generated by the tools are situated within this estimated range. The AFOLU Carb provides a value further away from the mean value. This is explained by the fact that the AFOLU Carb does not consider the land use change and therefore, does not compute emissions related to soil carbon losses.

140) The differences in results between the EX-ACT, CBP SA, and CAT-AR tools are minor: EX-ACT and CBP SA have a 1.6 percent difference, EX-ACT and CAT-AR a 0.88 percent difference, and CBP SA and CAT-AR a 0.8 percent difference. The difference in results between these tools and the AFD-CFT is higher: EX-ACT and AFD-CFT have a 15 percent difference, AFD-CFT and CBP SA a 13 percent difference, and AFD-CFT and CAT-AR a 14 percent difference. Based on this analysis, the four tools—EX-ACT, CBP, AFD-CFT, and CAT-AR—are suitable for the afforestation GHG analysis when considering grassland as ILU.

5.3.1.2 Annual crops development (ILU: degraded land)

141) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, AFOLU, CBP SA, AFD-CFT, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). The primary activity focused on developing annual crops in degraded areas. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −593.1 tCO_2eq per year and 565.6 tCO_2eq per year, with the 95 percent confidence interval of the mean between −1,043 and −136 tCO_2eq per year.

142) Except for the CCAFS-MOT and the AFOLU Carb, all the results generated by the tools are situated within this estimated range. The CCAFS-MOT tool does not consider all land use changes (only forest to grassland, arable to grassland, and grassland to arable) and has limited management options. Similarly, the AFOLU Carb does not consider all management practices (only tillage and inputs management) and land use changes. Although the CFT tool results are within the expected range, the tool does not provide a comparison of with and without the project scenarios, so an estimation of the carbon balance using the CCAFS-MOT and CFT tools was calculated separately (with and without the project scenarios) for the sake of comparison.

143) Only three tools—EX-ACT, CBP SA, and AFD-CFT—out of the six tools that have annual crops as an activity scope were able to estimate the mitigation benefit of this activity. The differences in results between the EX-ACT, CBP SA, and AFD-CFT tools are minor: EX-ACT and CBP SA have a 10 percent difference, EX-ACT and AFD-CFT a 9.4 percent difference, and CBP SA and AFD-CFT a 1 percent difference. This difference could be explained by the fact that the AFD-CFT and CBP SA tools do not consider degraded land

as an ILU.[14] Based on this analysis, the EX-ACT tool is suitable for GHG analysis of annual cropland development when considering degraded land as ILU.

5.3.1.3 Perennial crops development (ILU: degraded land)

144) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFD-CFT) were used to analyze perennial activities (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 2,049 tCO_2eq per year and the mean at −6,687.6 tCO_2eq per year. The 95 percent confidence interval of the mean is between −8,717 and −1,215 tCO_2eq per year.

145) Although the AFOLU Carb tool includes cropland management within its activity scope (Table 9), it does not differentiate between perennial and annual crops and was therefore not considered in this case. Except for the AFD-CFT, all the tools generated results within the estimated range. The AFD-CFT tool estimates a carbon balance value further away from the mean value.

146) The difference in results between the EX-ACT, CBP SA, and AFD-CFT tools varies: EX-ACT and CBP have a 13 percent difference, EX-ACT and AFD-CFT a 96 percent difference, and CBP and AFD-CFT an 86 percent difference. This could be explained by the different ILUs considered while running the calculations (degraded land for EX-ACT, abandoned cropland for AFD-CFT, and severely degraded grassland for the CBP SA). Based on this analysis, EX-ACT is suitable for GHG analysis of perennial cropland development when considering degraded land as ILU.

5.3.2 Project carbon balance

147) The total estimated carbon balance for the Brazil, Caatinga Conservation and Sustainable Management Project ranges between −18.6 and −16.2 tCO_2eq per hectare per year.

5.4 Burkina Faso, Third Phase Community Based Rural Development Project

148) The development objective of the project is to enhance the capacity of rural communities and decentralized institutions for the implementation of local development plans that promote sustainable land and natural resources management and productive investments at commune level. The project has five components:

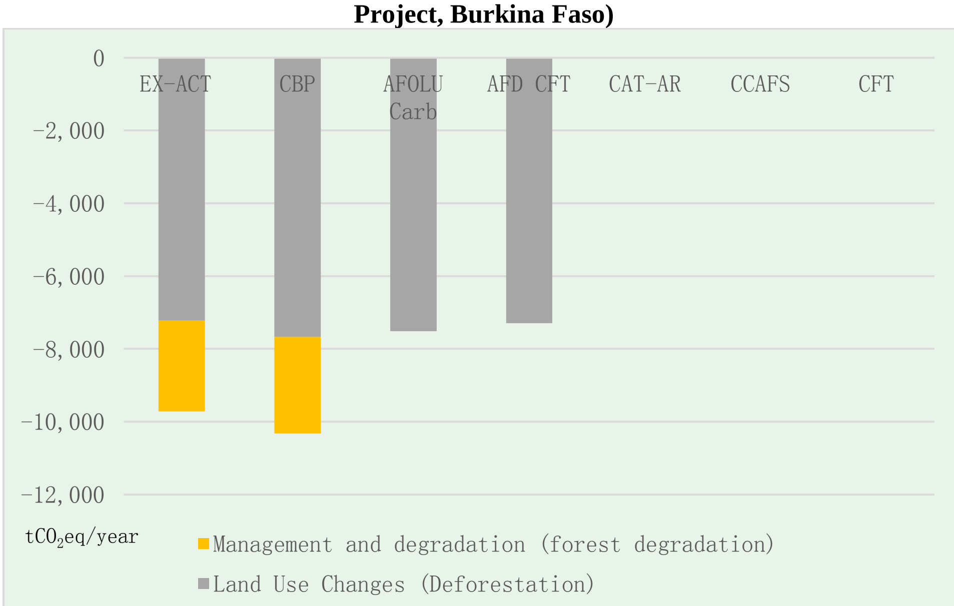
- Component 1: Strengthening capacity for decentralized rural development
- Component 2: Implementation of the rural land legislation and enhancement of local dispute resolution mechanisms
- Component 3: Local and regional investments

[14] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with degraded land corresponding values based on the IPCC methodology.

- Component 4: Sustainable land and forestry management
- Component 5: Project management, monitoring, and evaluation

149) Based on the scope and applicability of the tools, the activities in Component 4 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 5. The analyses focus on promoting community-based sustainable land and forestry management practices to reduce pressure on natural resources from competing land uses.

Figure 5: Carbon balance per component and per tool (Third Phase Community Based Rural Development Project, Burkina Faso)



150) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Burkina Faso/Africa
- Climate and moisture regime: Tropical dry
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

151) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.4.1 Detailed project analysis per activity for Burkina Faso Third Phase Community Based Rural Development Project

5.4.1.1 Deforestation (Final land use: grassland)

152) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFOLU Carb) were used to analyze deforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the

default coefficients generated by the tools were used. The mean and standard deviation are respectively −7,423.5 tCO_2eq per year and 203.8 tCO_2eq per year, with the estimated 95 percent confidence interval of the mean between −7,623 and −7,223 tCO_2eq per year.

153) All the tools provided results within this calculated range. The AFOLU Carb generated a value further away from the mean value. This can be explained by the fact that the AFOLU Carb is not based on the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions related to land use change.

154) The differences in results between the EX-ACT, CBP SA, and AFOLU Carb tools are minor: EX-ACT and CBP have a 5 percent difference, EX-ACT and AFOLU Carb a 3 percent difference, and CBP SA and AFOLU Carb a 2 percent difference. Based on this analysis, the three tools—EX-ACT, CBP and AFOLU Carb—are suitable for deforestation GHG analysis when considering grassland as final land use (FLU).

5.4.1.2 Forest management and degradation

155) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and CBP SA) were used to analyze forest management activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The AFOLU Carb tool is not considered within the analysis; although it considers forest protection activities, it does not consider the biomass losses that are not due to deforestation or illegal logging. The difference in results between the tools is minor (6.2 percent).[15] Based on this analysis, the EX-ACT and CBP tools are suitable for forest management GHG analysis.

5.4.2 Project carbon balance

156) For the overall project results, the CBP and EX-ACT tools provide relatively close results (0.08 tCO_2eq per year of difference). The uncertainty level for the CBP tool, (38 percent) is higher than that of EX-ACT (20 percent). Had the CBP DA been used instead of the SA, uncertainty could have been lowered substantially by using site-specific EFs.

5.5 Burundi, Sustainable Coffee Landscape Project

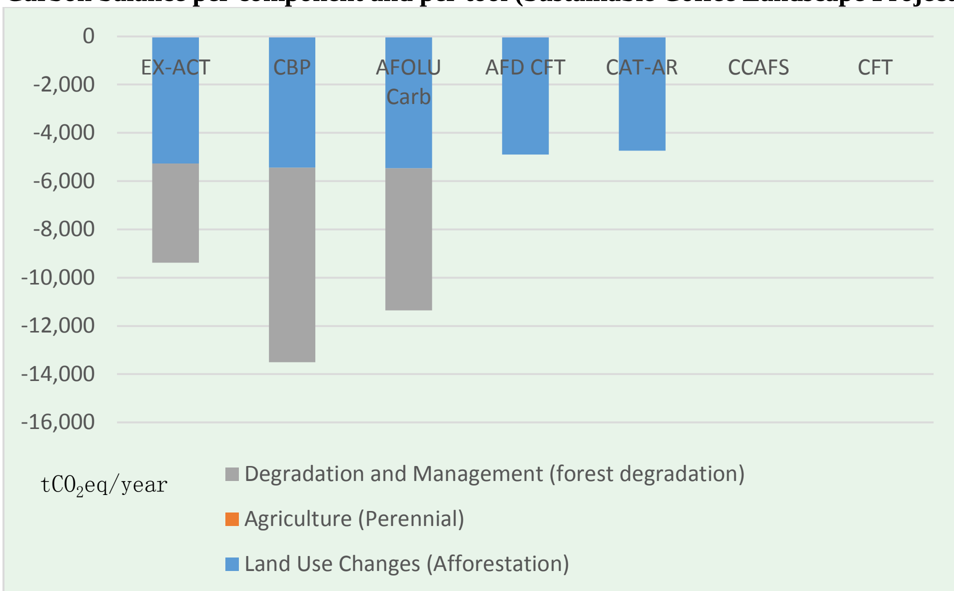
157) The development objective of the project is to pilot sustainable land and water management practices in the coffee landscape of Burundi. The project has four components:

- Component 1: Sustainable coffee landscape management
- Component 2: Addressing pollution point sources in coffee washing stations
- Component 3: Diversification of livelihoods
- Component 4: Knowledge and learning

[15] Using Tier 2 coefficients instead of Tier 1 methodology/coefficients could decrease the difference further.

158) Based on the scope and applicability of the tools, the activities in Component 1 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 6. The analyses focus on the promotion of sustainable land and water management, agroforestry, and shade grown coffee cultivation, as well as conservation activities in one protected area.

Figure 6: Carbon balance per component and per tool (Sustainable Coffee Landscape Project, Burundi)



159) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Burundi/Africa
- Climate and moisture regime: Tropical mountain moist
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 4 years and duration of analysis set to 20 years

160) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.5.1 Detailed project analysis per activity for the Burundi Sustainable Coffee Landscape Project

5.5.1.1 Afforestation/reforestation (ILU: set aside land)

161) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP SA, AFD-CFT, AFOLU, and CAT-AR) were used to analyze afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −5,163.2 tCO_2eq per year and 324.4 tCO_2eq per year

with the 95 percent confidence interval of the mean between −4,878 and −5,447 tCO_2eq per year.

162) The range of expected results allows us to observe the differences between the tools while analyzing afforestation activities. These differences are explained by the fact that the AFOLU tool does not account for the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools.

163) The differences in results between the EX-ACT, AFD-CFT, and CAT-AR tools are minor: EX-ACT and AFD-CFT have a 3 percent difference, EX-ACT and CAT-AR a 1 percent difference, and AFD-CFT and CAT-AR a 3 percent difference. The difference between the CAT-AR, CBP SA, AFD-CFT, and EX-ACT tools is explained by the fact that the analysis used Tier 1 methodology, and the absence of set aside land as ILU for the CBP SA tool. Based on this analysis, the three tools—CAT-AR, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering set aside land as ILU. It should be noted that the CBP DA could also be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land based on the IPCC methodology.

5.5.1.2 Perennial crops improvement

164) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, CBP SA, AFD-CFT, and CFT) were used to analyze perennial improvements (see Table 9). The results, however, are equal to zero. This is explained by the absence of Tier 2 values in the tools to describe the improved system (improved shaded coffee in our case).

165) All the four tools are suitable for GHG analysis of perennial improvements. Using Tier 2 values is recommended in such activity analysis; therefore, the CBP DA, rather than SA, should be used. Further analysis using the Tier 2 methodology will help understand and highlight the different characteristics between each of the tools.

5.5.1.3 Forest management and degradation

166) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and CBP SA) were used to analyze forest management activities (see Table 9). The AFOLU Carb tool is not considered within the analysis; although it considers forest protection activities, it does not consider the biomass losses that are not due to deforestation or illegal logging. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The difference in results between the tools is 12 percent. Based on this analysis, the EX-ACT and CBP tools are suitable for forest management GHG analysis.

5.5.2 Project carbon balance

167) For the overall project results, only the CBP and EX-ACT tools cover the appropriate areas of the project GHG appraisal and provide relatively similar results (−0.2 tCO_2eq per year difference). The uncertainty level is higher for the CBP tool at 51 percent, while the EX-ACT results are accompanied by an uncertainty level of 37 percent. Overall uncertainty depends on the uncertainty levels given to different factors by the IPCC and can be reduced in both CBP and EX-ACT by moving to a Tier 2 analysis (where the user supplies some of their own factors).

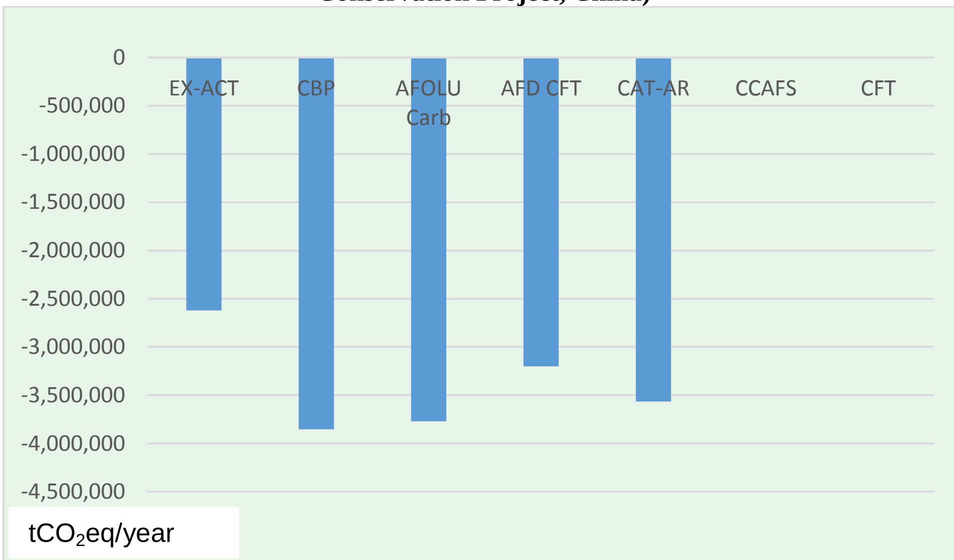
5.6 China, Guangxi Integrated Forestry Development and Conservation Project

168) The overall project development objective is to improve the effectiveness of forest management and institutional arrangements in timber production, watershed protection, and nature reserves management in selected areas of the Guangxi Zhuang Autonomous Region (GZAR). The project has four components:

- Component 1: Expanding timber plantations by financing
- Component 2: Increasing ecological forest cover
- Component 3: Strengthening management of nature reserves
- Component 4: Enhancing institutional and management capacity to implement an integrated institutional and management capacity-building program knowledge and learning

169) Based on the scope and applicability of the tools, the activities in Component 1 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 7. The analyses focus on expanding timber plantations and enlarging four central nurseries including setting up tissue culture plant, seedling shed, and irrigation.

Figure 7: Carbon balance per component and per tool (Guangxi Integrated Forestry Development and Conservation Project, China)



170) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: China/Asia continental
- Climate and moisture regime: Warm temperate moist
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 6 years and duration of analysis set to 20 years

171) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.6.1 Detailed project analysis per activity for Guangxi Integrated Forestry Development and Conservation Project

5.6.1.1 Afforestation (ILU: set aside and grassland)

172) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (CAT-AR, CBP SA, AFD-CFT, AFOLU Carb, and EX-ACT) were used to analyze afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 504,468 tCO_2eq per year and the mean at −3,402,056.2 tCO_2eq per year. The 95 percent confidence interval of the mean is between −2,959,869 and −3,844,242 tCO_2eq per year.

173) The range of expected results allows us to observe the differences between results while analyzing afforestation activities. These differences are explained by the fact that the

AFOLU Carb tool does not consider the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions related to land use change.

174) The differences in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools varies: EX-ACT and CBP have a 97 percent difference, EX-ACT and AFD-CFT a 20 percent difference, EX-ACT and CAT-AR a 30 percent difference, CBP and AFD-CFT an 82 percent difference, CBP and CAT-AR a 72 percent difference, and AFD-CFT and CAT-AR a 10 percent difference. The difference between the CAT-AR, CBP SA, AFD-CFT, and EX-ACT tools could be explained by the fact that Tier 1 methodology was applied, the absence of set aside land as ILU for the CBP SA tool, and the difference in the sources and sinks accounted for by the tools, and SLM activities considered by the tools (Tables 8 and 9).

175) Based on this analysis, the four tools—CAT-AR, AFD-CFT, CBP, and EX-ACT—are suitable for afforestation GHG analysis when considering grassland as ILU, while, the three tools—EX-ACT, CAT-AR, and AFD-CFT—are suitable when considering set aside land as the ILU. [16]

5.7 China, Shanghai Agricultural and Non-point Pollution Reduction Project

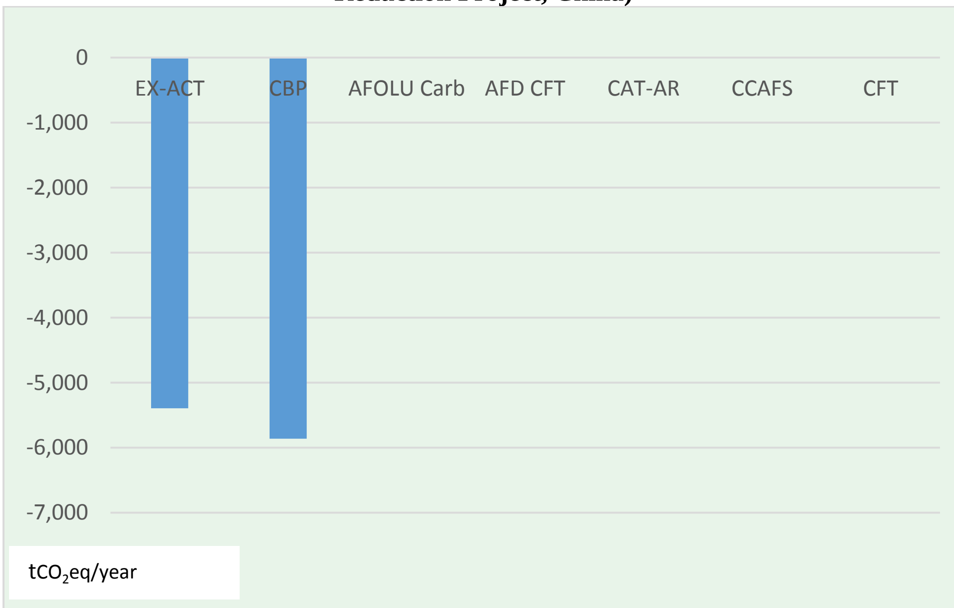
176) The objective of the project is to demonstrate effective and innovative pollution reduction activities in Shanghai's rural areas to reduce the rural and agricultural pollution load (especially nutrients) in the surface water flowing to the East China Sea. The project has four components:

- Component 1: Livestock waste management technology demonstration
- Component 2: Wetland demonstration for pollution reduction
- Component 3: Integrated agricultural pollution reduction techniques
- Component 4: Project management and dissemination

177) Based on the scope and applicability of the tools, the activities in Component 1 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 8. The analyses focus on the integration of livestock and agricultural waste management on large-scale and medium-scale farms. Within the analysis, we assume that cattle and swine's methane (CH_4) emissions from enteric fermentation and manure management are reduced by half with the project implementation.

[16] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land based on the IPCC methodology.

Figure 8: Carbon balance per component and per tool (Shanghai Agricultural and Non-point Pollution Reduction Project, China)



178) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: China/Asia continental
- Climate and moisture regime: Warm temperate moist
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

179) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.7.1 Detailed project analysis per activity for Shanghai Agricultural and Non-Point Pollution Reduction Project

5.7.1.1 Livestock

180) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, CBP DA, CCAFS-MOT, and CFT) were used to analyze livestock management activities (see Table 9). However, only two tools—EX-ACT and CBP DA—can estimate the total carbon balance, because these tools give the user the option of using Tier 2 values for livestock. The CFT tool does not allow the user to enter Tier 2 values for livestock; therefore, it is not possible to compare the with- and without-project GHG balance. Additionally, neither the CFT nor the CCAFS-MOT tool provides the user with options to analyze potential mitigation achieved through the improvement of feeding practices, manure management, and energy consumption.

181) The difference in results between the EX-ACT and CBP DA tools is minor (1 percent). Based on this analysis, the EX-ACT[17] and CBP tools are suitable for livestock GHG analysis using Tier 2 methodology.

5.7.2 Project carbon balance

182) The overall project result ranges between −0.51 and −0.55 tCO_2 per head per year. The uncertainty level is quite similar between the two tools—21 percent for the CBP tool and 20 percent for the EX-ACT tool.

5.8 Costa Rica, Biodiversity Conservation in Cacao Agroforestry

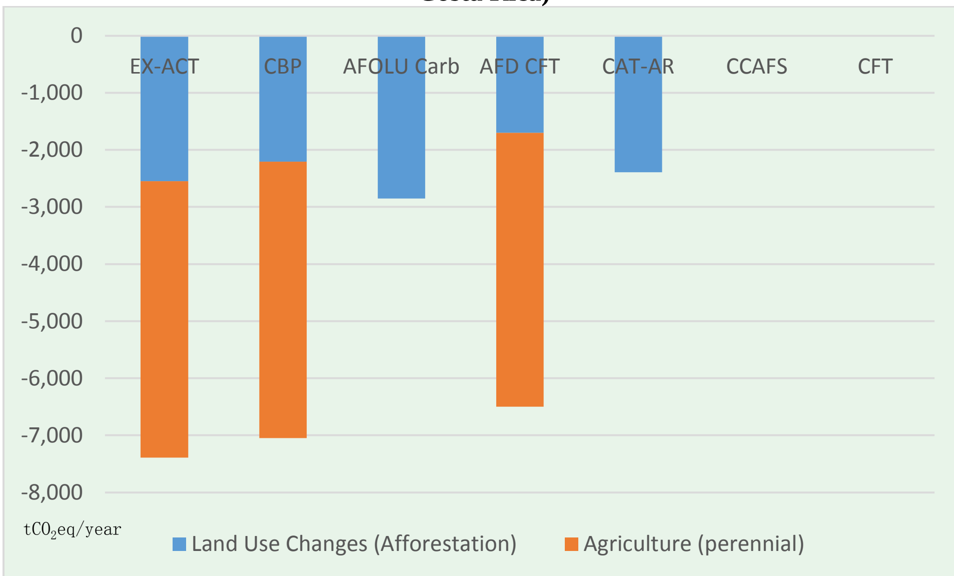
183) The rationale of the project is to improve the management of cacao-based poor indigenous small-farms according to both ecological and organic productive principles to ensure conservation and sustainable use of plant and animal diversity and provide a sustainable source of family income. The overall objective of the project is to promote and maintain on-farm biodiversity while improving livelihoods of organic cacao producers (indigenous, Latin mestizos, and Afro Caribbean groups) in the Talamanca-Caribbean corridor in Costa Rica. The project has four components:

- Component 1: Promotion and Conservation of On-Farm Biodiversity
- Component 2: Production, Certification & Marketing of Biodiversity-Friendly, Organic Products
- Component 3: Strengthening Farmers and Producers Organizations
- Component 4: Biodiversity and Monitoring

184) Based on the scope and applicability of the tools, the activities in Component 1 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 9. The analyses focus on rehabilitation planning of cocoa plantations.

[17] For users who wish to use detailed Tier 2 (for example, refined EFs on enteric fermentation) a link is provided by the EX-ACT tool to the FAO GLEAM-I tool.

Figure 9: Carbon balance per component and per tool (Biodiversity Conservation in Cacao Agroforestry, Costa Rica)



185) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Costa Rica/Central America
- Climate and moisture regime: Tropical moist
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 6 years and duration of analysis set to 20 years

186) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.8.1 Detailed project analysis per activity for Costa Rica Biodiversity Conservation in Cacao Agroforestry Project

5.8.1.1 Afforestation activities (ILU: set aside land)

187) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (CAT-AR, CBP SA, AFD-CFT, AFOLU Carb, and EX-ACT) were used to analyze afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 428 tCO_2eq per year and the mean at −2,338.8 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for afforestation activities should be between −1,963 and −2,714 tCO_2eq per year.

188) The range of expected results allows us to observe the differences between the tools while analyzing afforestation activities. These differences are explained by the fact that the AFOLU Carb does not consider the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions or removals as change over time of carbon stocks for the different pools. The difference in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools varies: EX-ACT and CBP have a 14 percent difference, EX-ACT and AFD-CFT a 25 percent difference, EX-ACT and CAT-AR a 6 percent difference, CBP and AFD-CFT a 39 percent difference, CBP and CAT-AR a 7 percent difference, and AFD-CFT and CAT-AR a 32 percent difference. The difference between the CAT-AR, CBP SA, AFD-CFT, and EX-ACT tools could be explained by the use of the Tier 1 methodology and the absence of set aside land as ILU for the CBP SA tool.

189) Based on this analysis, the three tools—CAT-AR, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering set aside land as the ILU change.[18]

5.8.1.2 Perennial crops improvement

190) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP DA, and AFD-CFT) were used to analyze perennial activities (see Table 9). The analysis consists of improving perennial crops management practices. To follow the Tier 2 methodology, the default Tier 1 coefficients were replaced to describe the initial and final (after improvements) above-ground growth rate (t C per ha per year), both to characterize the type of vegetation and the biomass growth. The mean and standard deviation are respectively −4,827 tCO_2eq per year and 23.38 tCO_2eq per year with the 95 percent confidence interval of the mean between −4,800 and −4,853 tCO_2eq per year.

191) All the results generated by the tools were situated within this estimated range. The differences in results between the EX-ACT, CBP, and AFD-CFT tools are minor: EX-ACT and CBP have a 2 percent difference, EX-ACT and AFD-CFT a 2 percent difference, and CBP and AFD-CFT a 5 percent difference.

192) Based on this analysis, the three tools—EX-ACT, CBP, and AFD-CFT—are suitable for perennial crops improvement GHG analysis using Tier 2 coefficients.

5.8.2 Project carbon balance

193) For the overall project results, the AFD-CFT, CBP DA, and EX-ACT tools cover the appropriate areas of the project GHG appraisal by providing relatively close results (0.62 tCO_2eq per ha per year of difference between the two extreme results −5.28 (CBP) and −5.9 (AFD-CFT) tCO_2eq per ha per year) to the estimated carbon count. The uncertainty

[18] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land based on the IPCC methodology.

level is higher for the CBP tool, at 62 percent, while the EX-ACT results are accompanied by an uncertainty level of 27 percent.

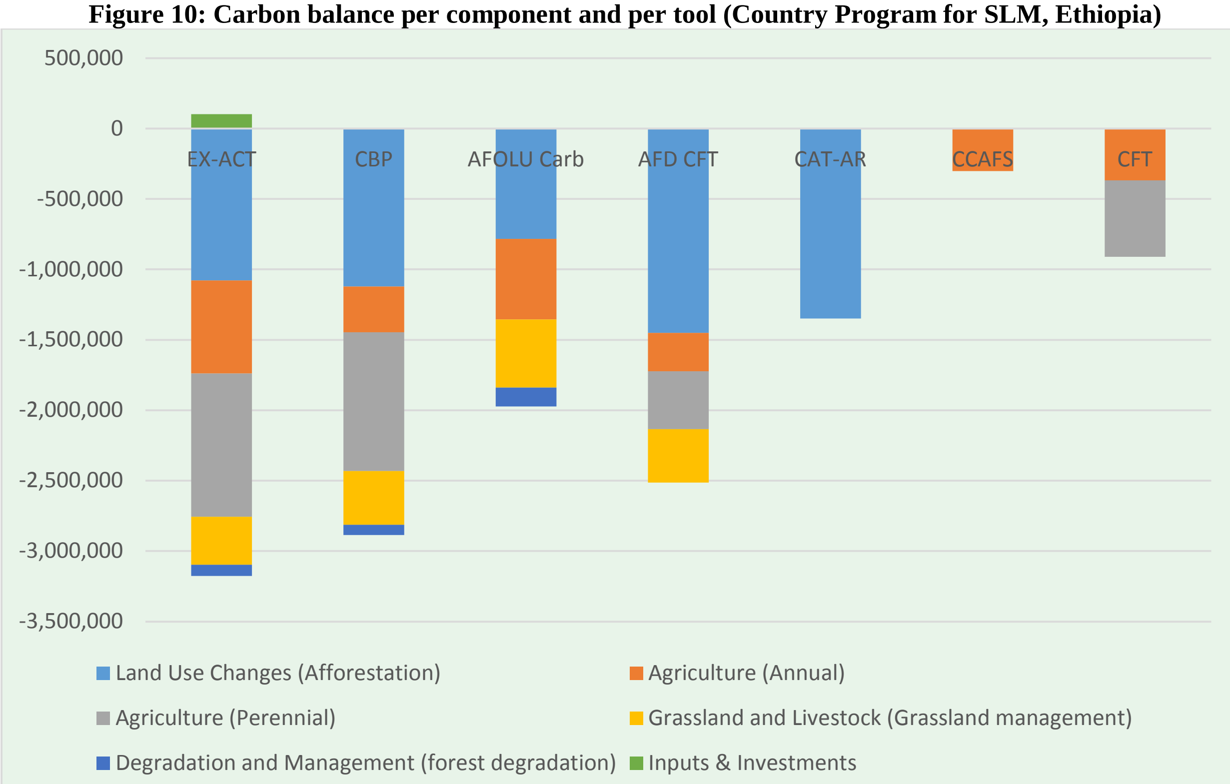
5.9 Ethiopia, Country Program for Sustainable Land Management (ECPSLM)

194) The objective of the proposed program is to conserve and restore landscapes of global and national ecological, economic, and social importance through the adoption of SLM policies, practices, and technologies. The four initial indicative components of the program or packages of activities to be developed under the program are the following:

- Component 1: Institutional strengthening
- Component 2: Actions on the ground to scale up SLM
- Component 3: Land Monitoring System
- Component 4: Program Coordination and Management

195) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 10. The analyses focus on scaling up SLM through the provision of financial and technical support to implement on a wider scale, with on-the-ground results, appropriate best practices, and technologies selected by the intended beneficiaries.

Figure 10: Carbon balance per component and per tool (Country Program for SLM, Ethiopia)



196) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Ethiopia/Africa
- Climate and moisture regime: Tropical dry
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

197) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.9.1 Detailed project analysis per activity for ECPSLM

5.9.1.1 Afforestation activities (ILU: set aside land and degraded land)

198) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (CAT-AR, CBP SA, AFD-CFT, AFOLU Carb, and EX-ACT) were used to analyze afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −3,402,056.2 tCO_2eq per year and 259,244 tCO_2eq per year, with the 95 percent confidence interval of the mean between −929,309 and −1,383,786 tCO_2eq per year.

199) The range of expected results allows us to observe the differences between the tools while analyzing afforestation activities. Several factors could contribute to this, including that the AFOLU Carb does not consider the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions related to land use change.

200) The differences in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools varies: EX-ACT and CBP have a 3 percent difference, EX-ACT and AFD-CFT a 29 percent difference, EX-ACT and CAT-AR a 22 percent difference, CBP and AFD-CFT a 25 percent difference, CBP and CAT-AR an 18 percent difference, and AFD-CFT and CAT-AR a 7 percent difference. Furthermore, the difference between the CAT-AR, CBP SA, AFD-CFT, and EX-ACT tools could be explained by the fact that the Tier 1 methodology and the absence of set aside land and degraded land as ILU for the CBP SA and of degraded land for the AFD-CFT.

201) Based on this analysis, the three tools—CAT-AR, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering set aside land as ILU.[19] The EX-ACT tool is also suitable for afforestation GHG analysis when considering degraded land as ILU change.

[19] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with set aside and degraded land corresponding values based on the IPCC methodology.

5.9.1.2 Annual cropland improvement

202) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, AFOLU Carb, CBP SA, AFD-CFT, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 159,745 tCO_2eq per year and the mean at −3,402,056.2 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for annual cropland activities should be between −288,854 and −544,500 tCO_2eq per year.

203) Except for the CBP and EX-ACT, all the results generated by the other tools were situated within a range of −270,000 and −370,000 tCO_2eq per year. However, the results generated by the CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT tools did not cover all the improved management options expressed within the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by halting residue burning and promoting zero tillage, while the project suggests that the annual crops improvements are improved agronomic practices, no tillage, water management, and manure application. Further, the CCAFS-MOT and CFT tools do not account for the gain-loss and stock difference carbon accounting. For the sake of comparison, the estimated carbon balance using the two tools (CCAFS-MOT and CFT tools) was calculated separately (without- and with-project scenarios).

204) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The difference in results between the EX-ACT and CBP tools is significant (68 percent). Based on this analysis, the two tools—EX-ACT and CBP—are suitable for annual crops' GHG analysis when considering improved practices scenarios.

5.9.1.3 Grassland management

205) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, AFOLU Carb, CBP SA, and AFD-CFT) were used to analyze grassland management activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −363,371 tCO_2eq per year and 20,268 tCO_2eq per year, with the 95 percent confidence interval of the mean between −333,508 and −383,233 tCO_2eq per year.

206) All the results generated by the tools were situated within this estimated range. The differences in the results generated by the tools were mainly due to the use of different IPCC GHG accounting approaches and carbon pools (Tables 8 and 10). For example, the

AFD-CFT tool calculates the default soil carbon stock changes based on a set of IPCC criteria, whereas, the AFOLU Carb provides estimated values for relative stock change factors based on the project location.

207) The difference in results between the tools varies: EX-ACT and CBP have a 10 percent difference, EX-ACT and AFD-CFT a 12 percent difference, EX-ACT and AFOLU Carb a 33 percent difference, CBP and AFD-CFT a 1 percent difference, CBP and AFOLU Carb a 23 percent difference, and AFD-CFT and AFOLU Carb a 23 percent difference.

5.9.1.4 Forest management and degradation

208) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and CBP SA) were used to analyze forest management and degradation activities (see Table 9). Since the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The AFOLU Carb tool is not considered within the analysis; although it considers forest protection activities, it does not consider the biomass losses that are not due to deforestation or illegal logging. The difference in results between the EX-ACT and CBP tools is relatively small (6.2 percent). Based on this analysis, the two tools—EX-ACT and CBP—are suitable for forest management GHG analysis.

5.9.1.5 Inputs and Investments (electricity, irrigation, buildings, and roads construction)

209) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and AFD-CFT) were used to analyze inputs and investments activities (see Table 9)—in the project's case, electricity, irrigation, buildings, and roads. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The difference in results is explained by the tools' different coverage of the activities. Based on this analysis, the EX-ACT and AFD-CFT tools are suitable for the electricity, buildings, and roads construction GHG analysis, while EX-ACT also can be used to analyze activities related to the installation of new irrigation infrastructure.

5.9.2 Project carbon balance

210) For the overall project results, the EX-ACT tool covers the aspects of the project GHG appraisal. The estimated carbon balance is −66,317,269 tCO_2eq for the entire duration of the analysis (20 years) or 3 tCO_2 per ha per year. The uncertainty level is 39 percent.

5.10 Guinea, Community-based Land Management Project

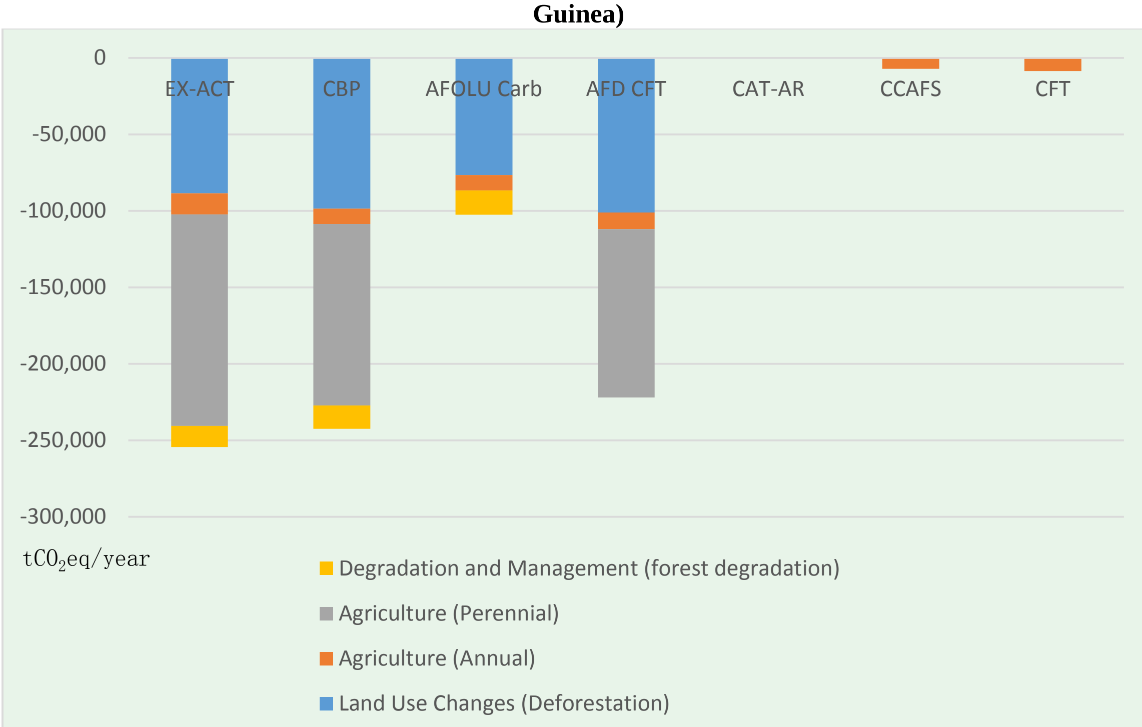
211) The development objective of the project is to reduce land degradation through the integration of SLM practices into the overall development planning process of communities and local governments in selected pilot sub-watersheds. The global objective of the project is to pilot sustainable and replicable approaches to the prevention and mitigation of the

causes and negative impacts of land degradation on the structure and functional integrity of ecosystems. The project has three components:

- Component 1: Local Investment Fund
- Component 2: Capacity Building for Local Development
- Component 3: Project Management, Coordination, and Monitoring and Evaluation

212) Based on the scope and applicability of the tools, the activities in Component 1 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 11. The analyses focus on enhancing SLM focused investments and supporting the demonstration of practices that would reduce land degradation.

Figure 11: Carbon balance per component and per tool (Community-based Land Management Project, Guinea)



213) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Guinea/Africa
- Climate and moisture regime: Tropical moist
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 8 years and duration of analysis set to 20 years

214) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.10.1 Detailed project analysis per activity for the Guinea Community-based Land Management Project

5.10.1.1 Deforestation activities (FLU: set aside land and annual cropland)

215) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFOLU Carb) were used to analyze deforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 11,083 tCO_2eq per year and the mean at −91,180 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for deforestation activities should be between −80,318 and −102,042 tCO_2eq per year.

216) All the tools provided results within this calculated range. The AFOLU Carb generated a value further away from the mean value. This is explained by the fact that the AFOLU Carb does not account for the gain-loss and stock difference methods, and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools.

217) The differences in results between the tools varies:[20] EX-ACT and CBP have a 10 percent difference, EX-ACT and AFOLU Carb a 14 percent difference, and CBP SA and AFOLU Carb a 24 percent difference. Based on this analysis, the three tools—EX-ACT, CBP, and AFOLU Carb—are suitable for deforestation GHG analysis when considering annual cropland as the FLU.

5.10.1.2 Annual cropland improvement

218) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, CBP SA, AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). Since the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −10,154 tCO_2eq per year and 2,286 tCO_2eq per year. The 95 percent confidence interval of the mean is between −8,325 and −11,983 tCO_2eq per year.

219) Except for the CBP SA and EX-ACT, all the results generated by the tools were situated within this range. However, the results generated by the CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT tools are underestimated and do not cover all the improved management options expressed within the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by stopping the residue burning and incorporating zero tillage. Furthermore, the CCAFS-MOT and CFT

[20] Using the Tier 2 methodology/coefficients, instead of Tier 1, could further decrease the difference.

tools do not provide a comparison of with and without the project scenario. The estimated carbon balance using the two tools (CCAFS-MOT and CFT tools) was calculated separately (without and with the project scenarios) for the sake of comparison.

220) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The differences in results between the EX-ACT and CBP tools is 31 percent. Based on this analysis, the two tools—EX-ACT and CBP—are suitable for annual crops GHG analysis when considering improved practices scenarios.

5.10.1.3 Perennial cropland development (ILU: annual crops)

221) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, AFD-CFT) were used to analyze perennial activities (see Table 9). Although the AFOLU Carb tool includes cropland management within its activity scope, it was not used because it does not differentiate between perennial and annual crops (Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 2,621 tCO_2eq per year and the mean at −107,022 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for perennial cropland development activities should be between −81,328 and −132,715 tCO_2eq per year.

222) All the results generated by the tools were situated within this estimated range. The AFD-CFT tool estimated a carbon balance value further away from the mean value. Furthermore, the differences in results between the tools varies: EX-ACT and CBP have a 15 percent difference, EX-ACT and AFD-CFT a 42 percent difference, and CBP SA and AFD-CFT a 27 percent difference. Based on this analysis, the three tools—EX-ACT, CBP, and AFD-CFT—are suitable for perennial development GHG analysis when considering annual cropland as ILU change.

5.10.1.4 Forest management and degradation (forest fire management)

223) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools—EX-ACT, CBP SA, and AFOLU Carb—were used to analyze forest management and degradation activities (see Table 9). The analysis was conducted following the Tier 1 methodology, and as such, the default coefficients generated by the tools were used.

224) Although the AFOLU Carb tool takes into account the fire impact, the difference in results is explained by the suggested default Forest Carbon Stock value, which is the average of the above- and below-ground forest carbon stock in the tree pool (Table 8). The differences in results between the tools varies: EX-ACT and CBP have a 9 percent

difference, EX-ACT and AFOLU Carb a 13 percent difference, and CBP SA and AFOLU Carb a 3.94 percent difference. This difference could be explained by the fact the CBP does not consider fire occurrence lower than 1.0 percent, and the activity suggests that the fire impact (percent burnt) will be reduced from 0.2 percent to 0.1 percent yearly with the project implementation. Based on this analysis, the three tools—EX-ACT, CBP, and AFOLU Carb—are suitable for GHG analysis of forest fire management.

5.10.2 Project carbon balance

225) For the overall project results, the scope of the CBP and EX-ACT tools covers the appropriate areas for the overall objectives of the project. Both tools provided relatively similar results within the range of 0.2 tCO_2eq per year difference. Despite this, the uncertainty level is higher for the EX-ACT tool at 44 percent, while the CBP results are accompanied by an uncertainty level of 37 percent.

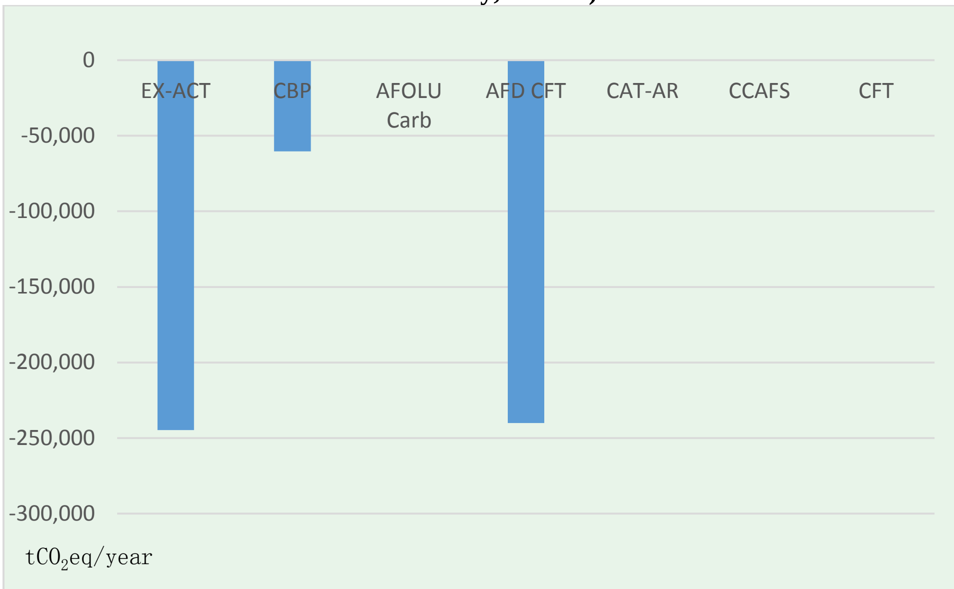
5.11 Jordan, Integrated Ecosystem Management in the Jordan Rift Valley

226) The development objective of the Jordan Rift Valley project is to apply the principles of integrated ecosystem management to the existing land use master plan of the Jordan Rift Valley and establish a network of well-managed protected areas that meets local ecological, social, and economic needs. The project has five components:

- Component 1: Assessment and Planning for Integrated Ecosystem Management
- Component 2: Development of a network of biodiversity conservation sites
- Component 3: Integrated Assessments of Climate Change Impacts on Biodiversity Conservation
- Component 4: Strengthening sustainable financing mechanisms
- Component 5: Project management, coordination, and M&E

227) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 12. The analyses focus on developing a network of biodiversity conservation sites, embodying the principles of integrated ecosystem management.

Figure 12: Carbon balance per component and per tool (Integrated Ecosystem Management in the Jordan Rift Valley, Jordan)



228) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Jordan/Middle East
- Climate and moisture regime: Warm temperate dry
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 6 years and duration of analysis set to 20 years

229) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.11.1 Detailed project analysis per activity for the Jordan Integrated Ecosystem Management in the Jordan Rift Valley Project

5.11.1.1 Grassland development (ILU: set aside land)

230) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFD-CFT) were used to analyze grassland development activities (see Table 9). Since the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The activity consists of developing grassland on set aside land.

231) The differences in the results generated by the tools are mainly due to the difference in the EFs and carbon stock change values associated with the Tier 1 methodology. For instance, the CBP SA does not take 'set aside land' as an ILU. Thus, it was replaced by severely degraded grassland. The difference in results between EX-ACT and AFD-CFT is

minor (9 percent difference). Based on this analysis, the EX-ACT and AFD-CFT tools are suitable for grassland development GHG analysis when considering set aside land as the ILU.[21]

5.12 Mali, Natural Resources Management in a Changing Climate

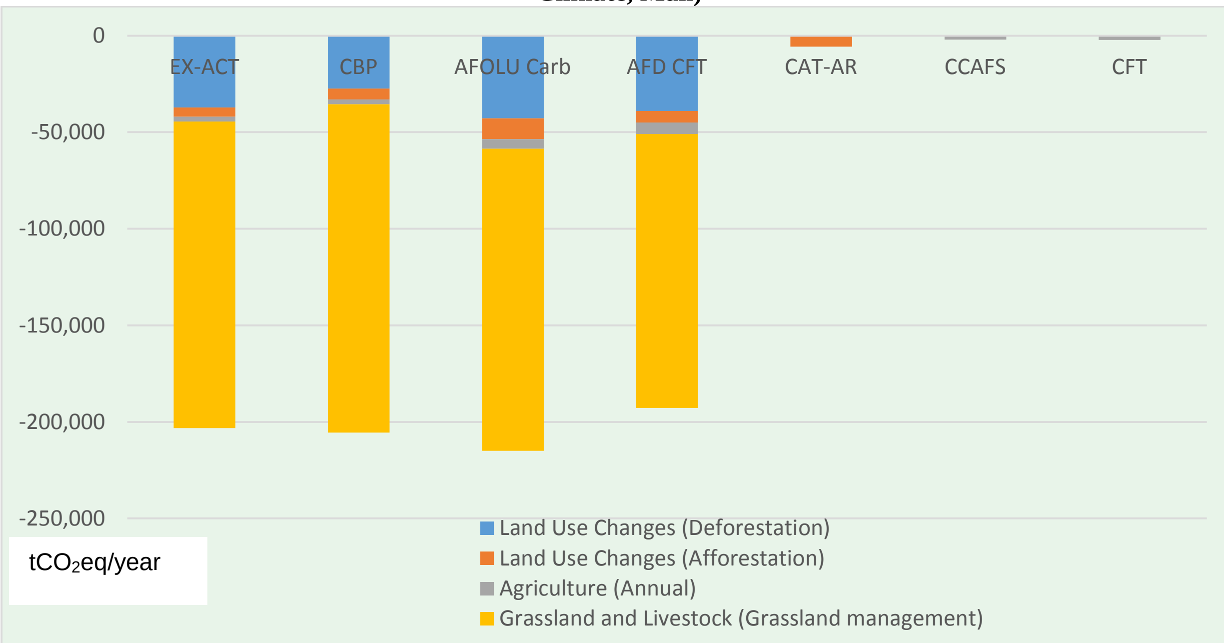
232) The project development objective is to secure the ecological integrity of the sites as globally important ecological corridors and migratory flyways, through a combination of integrated land use planning, ecologically appropriate and nature-based socioeconomic development, and biodiversity protection and management. The project has four components:

- Component 1: Knowledge management, Governance, and Communication
- Component 2: Scaling-up Sustainable land management practices
- Component 3: Diversification of local livelihoods
- Component 4: Project coordination, monitoring, and evaluation

233) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 13. The analyses focus on (a) scaling up SLM practices, (b) improving the sustainable use of biodiversity resources in the targeted areas, (c) reversing the reduction of forest coverage, and (d) strengthening the resilience of rural producers' assets in the targeted areas and communities to climate change challenges.

[21] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land based on the IPCC methodology.

Figure 13: Carbon balance per component and per tool (Natural Resources Management in a Changing Climate, Mali)



234) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Mali/Africa
- Climate and moisture regime: Tropical dry
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

235) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.12.1 Detailed project analysis per activity for the Mali Natural Resources Management in a Changing Climate Project

5.12.1.1Deforestation (FLU: grassland)

236) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFOLU Carb) were used to analyze deforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 6,593.9 tCO_2eq per year and the mean at −36,567.75 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for deforestation activities should be between −30,105 and −43,029 tCO_2eq per year.

237) Except for the CBP SA, all the tools generated results within this estimated range. The AFOLU Carb generated a value further away from the mean value, which can be explained by the fact that the AFOLU Carb does not account for the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools.

238) The differences in results between the EX-ACT, CBP, and AFOLU Carb tools varies: EX-ACT and CBP have a 54 percent difference, EX-ACT and AFOLU Carb a 14 percent difference, and CBP and AFOLU Carb a 66 percent difference. Using the Tier 2 coefficients instead of Tier 1 methodology could further decrease the difference. Based on this analysis, the three tools—EX-ACT, CBP, and AFOLU Carb—are suitable for deforestation GHG analysis when considering grassland as the FLU.

5.12.1.2 Afforestation activities (ILU: set aside land and degraded land)

239) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP SA, AFOLU Carb, AFD-CFT, and CAT-AR) were used to analyze afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −6,608.6 tCO_2eq per year and 2,366 tCO_2eq per year, with 95 percent confidence interval of the mean between −4,534 and −8,682 tCO_2eq per year.

240) Except for the AFOLU Carb tool, all the results generated by the tools are situated within this estimated range. The AFOLU Carb tool does not account for the gain-loss and stock difference methods, and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools (Table 8). The differences in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools varies: EX-ACT and CBP have a 54 percent difference, EX-ACT and AFD-CFT a 19 percent difference, and CBP and AFD-CFT a 71 percent difference. The differences observed between the CAT-AR, CBP SA, AFD-CFT, and EX-ACT tools could be explained by the fact that Tier 1 methodology/coefficients, different GHG accounting approaches, and carbon pools were applied in the analyses (Table 8).

241) Based on this analysis, the three tools—CAT-AR, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering set aside land as ILU, while, the EX-ACT tool is suitable for afforestation GHG analysis when considering degraded land as ILU.[22]

5.12.1.3 Annual cropland improvement

[22] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land and degraded land based on the IPCC methodology.

242) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, CBP SA, AFD-CFT, AFOLU, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). The activity consists of improving management practices of annual crops. The analysis was conducted following the Tier 1 methodology; therefore, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −3,402,056.2 tCO_2eq per year and 159,745 tCO_2eq per year. The estimated confidence interval of the mean is between −288,854 and −544,500 tCO_2eq per year.

243) Except for the CBP SA and EX-ACT tools, all the results generated by the tools were situated within a range of −2,383 and −2,499 tCO_2eq per year. However, the results generated by the CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT tools were underestimated as they did not reflect all the improved management options expressed within the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by stopping the residue burning and incorporating zero tillage, while the project suggests that the annual crops improvements are improved agronomic practices, nutrient management, residue management, and manure application. Further to this, the CCAFS-MOT and CFT tools are not based on gain-loss and stock difference methods (Table 8). The estimated carbon balance using the two tools (CCAFS-MOT and CFT tools) was calculated separately (without and with the project scenarios) for the sake of comparison. As for the AFOLU Carb tool, it considers only two improvements, the tillage (full, reduced, and no-till) and inputs (low, medium, high with and without manure), to describe the improved management options for annual cropland.

244) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The differences in results between the EX-ACT and CBP tools is high (70 percent). Based on this analysis, the two tools, EX-ACT and CBP, are suitable for annual crops GHG analysis when considering improved practices scenarios.

5.12.1.4 Grassland management

245) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, CBP SA, AFOLU Carb, and AFD-CFT) were used to analyze grassland management activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −156,784 tCO_2eq per year and 11,546 tCO_2eq per year with 95 percent confidence interval of the mean between −145,468 and −168,100 tCO_2eq per year.

246) All the results generated by the tools were situated within this estimated range. The difference in the results generated is mainly due to the difference in the EFs and carbon stock change values associated with the Tier 1 methodology. For example, the AFD-CFT tool calculates the default soil carbon stock changes based on a set of IPCC criteria, whereas the AFOLU Carb provides estimated values for relative stock change factors (Table 8).

247) The differences in results between the EX-ACT, CBP, AFD-CFT, and AFOLU tools varies: EX-ACT and CBP have a 6 percent difference, EX-ACT and AFD-CFT a 20 percent difference, EX-ACT and AFOLU Carb a 2 percent difference, CBP and AFD-CFT a 14 percent difference, CBP and AFOLU Carb an 8 percent difference, and AFD-CFT and AFOLU Carb a 22 percent difference. Based on this analysis, the four tools—EX-ACT, CBP, AFD-CFT, and AFOLU Carb—are suitable for grassland management GHG analysis.[23]

5.12.2 Project carbon balance

248) For the overall project results, four tools—the CBP, EX-ACT, AFD-CFT, and AFOLU Carb—have a scope that covers all project activities. The tools provide relatively close results (see Table 14). The uncertainty level for the CBP tool equals 32 percent, while the EX-ACT results are accompanied by an uncertainty level of 48 percent due to the use of Tier 1 methodology.

Table 14: Carbon balance results for the Mali Natural Resources Management in a Changing Climate Project

Tools (tCO_2eq)	**EX-ACT**	**CBP**	**AFOLU Carb**	**AFD CFT**
Total	**−4,065,339**	**−4,110,680**	**−4,300,499**	**−3,618,000**
Total per year	**−203,267**	**−205,534**	**−215,025**	**−180,900**
Per hectare	**−34**	**−34.7**	**−36.3**	**−30.6**
Per hectare per year	**−1.72**	**−1.74**	**−1.82**	**−1.53**

5.13 Moldova, Agriculture Competitiveness Project

249) The development objective of the Agriculture Competitiveness Project for Moldova is to enhance the competitiveness of the country’s agrofood sector by supporting the modernization of the food safety management system, facilitating market access for farmers, and mainstreaming agro-environmental and SLM practices. The project has five components:

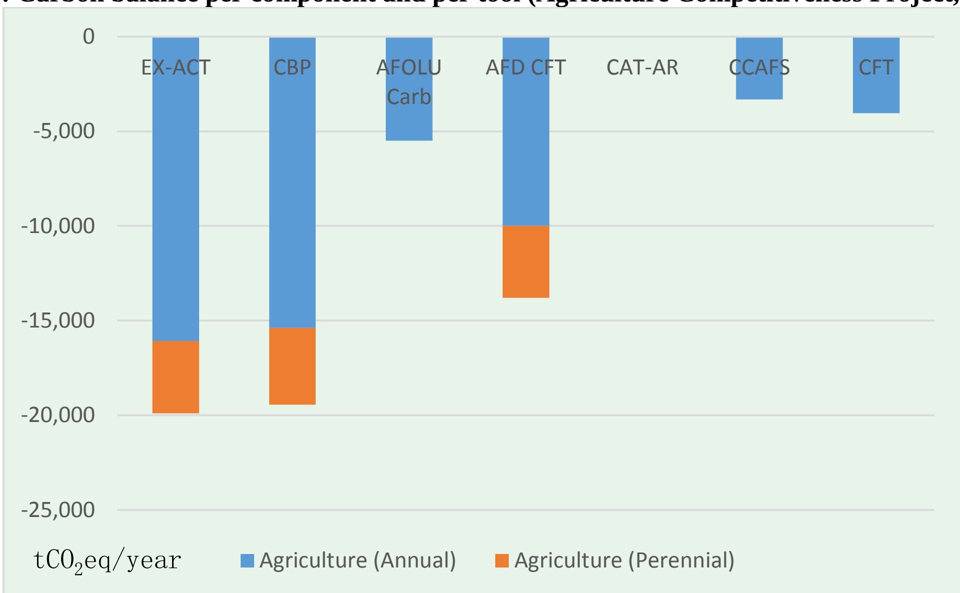
- Component 1: Enhancing food safety management
- Component 2: Enhancing market access potential
- Component 3: Enhancing land productivity through sustainable land management
- Component 4: Project management

[23] It should be noted that the specific value of organic carbon present in soils should be generated for the AFOLU Carb tool.

- Component 5: Compensatory sales support grants

250) Based on the scope and applicability of the tools, the activities in Component 3 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 14. The analyses focus on enhancing land productivity through SLM, supporting activities to mainstream SLM practices and technologies, and rehabilitating anti-erosion shelterbelts.

Figure 14: Carbon balance per component and per tool (Agriculture Competitiveness Project, Moldova)



251) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Moldova/Eastern Europe
- Climate and moisture regime: Warm temperate moist
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

252) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.13.1 Detailed project analysis per activity for the Moldova Agriculture Competitiveness Project

5.13.1.1 Annual cropland improvement

253) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, AFOLU Carb, CBP SA, AFD-CFT, CCAFS-MOT, CFT) were used to analyze annual cropland activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The activity

consists of improving management practices of annual crops. The mean and standard deviation are respectively −9,056 tCO_2eq per year and 5,674 tCO_2eq per year with the 95 percent confidence interval of the mean between −4,516 and −13,596 tCO_2eq per year.

254) Except for the CBP SA and EX-ACT tools, all the results generated by the other tools were situated within a range of −2,383 and −2,499 tCO_2eq per year. However, underestimation occurs for CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT and do not reflect all the improved management options cited in the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by stopping the residue burning and incorporating zero tillage, while the project suggests that the annual crops improvements are improved agronomic practices, nutrient management, residue management, and manure application. Furthermore, the CCAFS-MOT and CFT tools do not provide a comparison of with and without the project scenarios. The estimated carbon balance using the two tools (CCAFS-MOT and CFT tools) was calculated separately (without and with the project scenarios) for the sake of comparison. As for the AFOLU Carb tool, it considers only two improvements, the tillage (full, reduced, and no-till) and inputs (low, medium, high with and without manure), to describe the improved management options for annual cropland.

255) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The difference in results between the EX-ACT and CBP tools is high (31 percent). Based on this analysis, the two tools—EX-ACT and CBP—are suitable for annual crops GHG analysis when considering improved practices scenarios.

5.13.1.2 Perennial cropland improvement

256) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP DA, and AFD-CFT) were used to analyze perennial activities. The activity analysis consists of improving perennial crops management practices. To follow the Tier 2 methodology, the default Tier 1 coefficients were replaced to describe the initial and final (after improvements) above-ground growth rate (tC per ha per year). This was done to characterize both the type of vegetation and the biomass growth.

257) The difference in results generated by the tools is minor: EX-ACT and CBP DA have a 5.0 percent difference, AFD-CFT and CBP DA a 6.0 percent difference, and EX-ACT and AFD-CFT a 0.5 percent difference. Based on this analysis, the three tools—EX-ACT, CBP DA, and AFD-CFT—are suitable for perennial improvements GHG analysis when considering set aside land as the ILU.

5.13.2 Project carbon balance

258) The project objectives' scope is covered by three tools—the CBP, EX-ACT, and AFD-CFT. The tools provided relatively close results (see Table 15). The uncertainty level for the CBP tool equals 40 percent, while an uncertainty level of 46 percent accompanies the EX-ACT results.

Table 15: Carbon balance results for Agriculture Competitiveness Project.

Carbon Balance (tCO_2eq)	**EX-ACT**	**CBP**	**AFD-CFT**
Total	**−397,955**	**−412,320**	**−300,000**
Total per year	**−19,897.76**	**−16,216.00**	**−15,000**
Per hectare	**−39.80**	**−41.232**	**−30**
Per hectare per year	−1.99	−2.06	−1.5

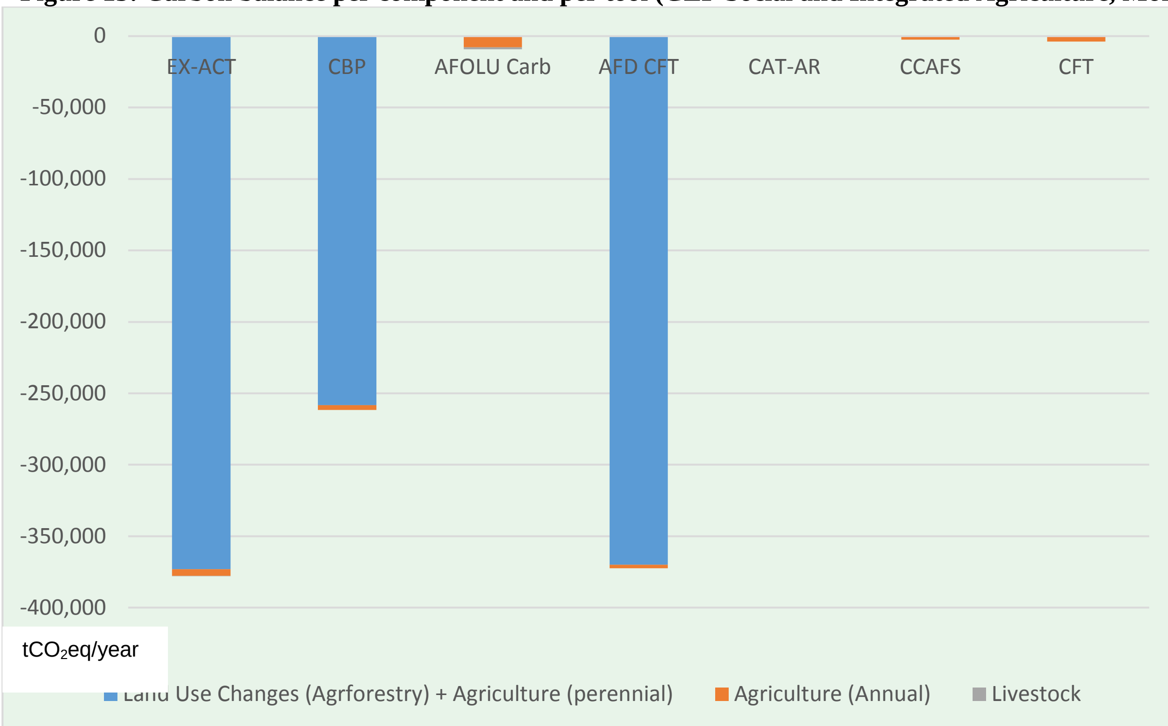
5.14 Morocco, GEF Social and Integrated Agriculture (ASIMA)

259) The project development objective is to increase the implementation of land and biodiversity conservation measures in selected projects directed at small farmers located in targeted marginal areas in the project area. The project has two components:

- Component 1: Development of the capacities of public and private institutions on land and biodiversity conservation
- Component 2: Transfer of land and biodiversity conservation measures among small farmers

260) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 15. The analyses focus on promoting land and biodiversity conservation measures in specific agri-food chains typical of marginal areas.

Figure 15: Carbon balance per component and per tool (GEF Social and Integrated Agriculture, Morocco)



261) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Morocco/Africa
- Climate and moisture regime: Warm temperate dry
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

262) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.14.1 Detailed project analysis per activity for the Morocco GEF Social and Integrated Agriculture (ASIMA)

5.14.1.1 Perennial cropland development (ILU: degraded land)

263) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFD-CFT) were used to analyze perennial activities (see Table 9). Because the activity analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used.

264) The difference in results between the tools varies: EX-ACT and CBP SA have a 36 percent difference, EX-ACT and AFD-CFT a 0.82 percent difference, and CBP and AFD-

CFT a 35.5 percent difference. The high difference in results provided by the CBP SA tool could be explained by the uncertainty related to the Tier 1 methodology as well as the consideration of severely degraded grassland instead of degraded land as ILU for the CBP SA.

265) Based on this analysis, the EX-ACT is a suitable tool for perennial cropland development GHG analysis when considering degraded land as ILU.[24]

5.14.1.2 Annual cropland improvement

266) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, CBP SA, AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). The activity consists of improving the management practices of annual crops. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The mean and standard deviation are respectively −4,123.5 tCO_2eq per year and 2,074 tCO_2eq per year with the 95 percent confidence interval of the mean between −2,463 and −5,783 tCO_2eq per year.

267) Except for the CBP SA and EX-ACT, all the results generated by the tools were situated within this range. However, the results generated by the CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT tools are underestimated and do not reflect all the improved management options expressed within the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by stopping residue burning and incorporating zero tillage, while the project suggests that the annual crops improvements are improved agronomic practices, no tillage, water management, and manure application. Furthermore, the CCAFS-MOT and CFT tools do not provide a comparison of with and without the project scenario and do not account for the gain-loss and stock difference methods. The estimated carbon balance using the two tools (CCAFS-MOT and CFT tools) was calculated separately (without and with the project scenarios) for the sake of comparison. As for the AFOLU Carb tool, it considers only two improvements, the tillage (full, reduced, and no-till) and inputs (low, medium, high with and without manure), to describe the improved management options for annual cropland.

268) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The difference in results between the EX-ACT and CBP tools is high (30 percent).

[24] The CBP and AFD tools default values should be replaced with corresponding carbon stock values for degraded land based on the IPCC methodology.

269) Based on this analysis, the EX-ACT and CBP are suitable for annual crops GHG analysis when considering improved practices scenarios.

5.14.1.3 Livestock

270) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP, CCAFS-MOT, AFOLU Carb, and CFT) were used to analyze livestock management activities (see Table 9). The activity consists of improving the management practices of livestock. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. However, as the analysis required more technical mitigation options,[25] only the EX-ACT and AFOLU Carb tools were able to generate an estimate of the total carbon balance for the livestock activities. The AFOLU Carb and CBP SA tools consider the number of livestock without any technical mitigation options, therefore, the carbon balance is 0 tCO_2eq. The CBP DA tool does allow the user to input their own factors associated with technical mitigation options, but the DA was not used in this analysis. The CFT also has a few limiting factors, including no opportunity for the user to insert Tier 2 values and to compare with and without project scenarios. However, the CFT and CCAFS-MOT tools do provide the user with options on feeding practices, manure management, and energy consumption.

271) Based on this analysis, the analysis found that the EX-ACT tool is the most suitable for livestock GHG analysis when considering technical mitigation options (feeding practices, specific agents, and breeding practices) and the CBP DA can also be used if the user has their own EF data.[26]

5.15 Serbia, Contribution of Sustainable Forest Management to a Low Emission and Resilient Development Project

272) The project aims to promote SFM practices among the actors of the public and private sector, strengthening their capacities of mainstreaming biodiversity conservation and management of carbon stocks into forest management planning and implementation. The project components are the following:

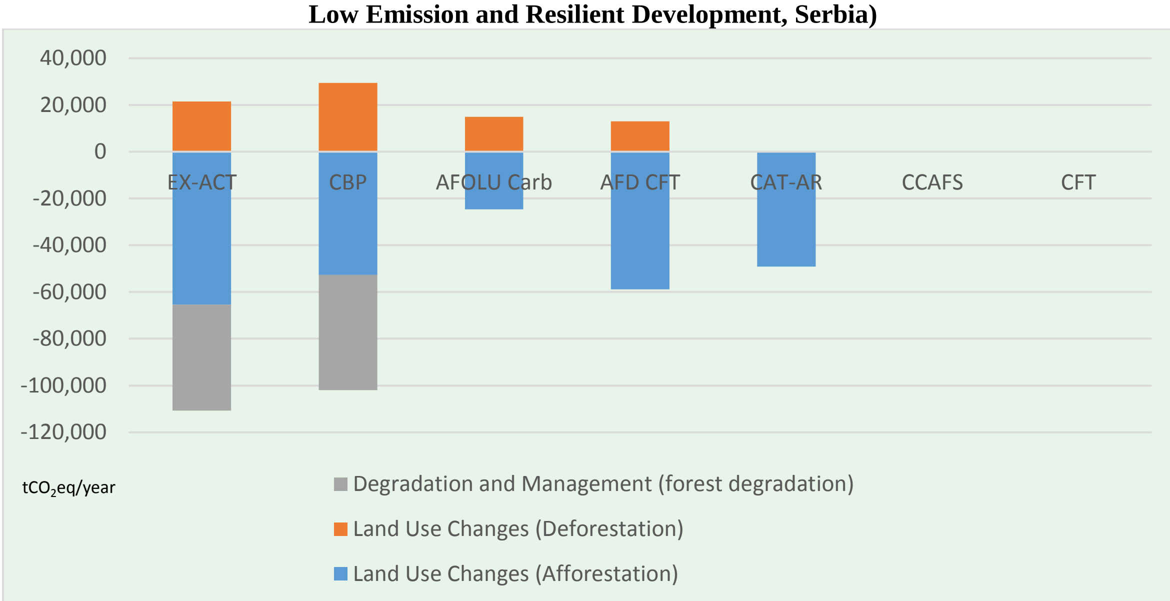
- Component 1: Enabling environment for multifunctional sustainable forest management
- Component 2: Multifunctional forest management
- Component 3: Monitoring, evaluation, and lessons dissemination

[25] Methane emissions are affected by a number of factors including the animal traits (for example, age, bodyweight, and genetics) and environmental parameters (for example, temperature) but also feed quality. Therefore, mitigation options would have to address those last drivers. Smith et al. (2008) reviewed the mitigation potentials linked mostly with animal and feed factors and reported that they could be categorized more precisely into improved feeding practices, use of specific agents or dietary additives, and longer-term management changes and animal breeding.

[26] For users who wish to use detailed Tier 2 (for example, refined EFs on enteric fermentation) a link is provided by the EX-ACT tool to the FAO GLEAM-I tool.

273) Based on the scope and applicability of the tools, the activities in Component 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 16. The analyses focus on increasing forest area under sustainable and multifunctional forest management to enhance carbon sequestration.

Figure 16: Carbon balance per component and per tool (Contribution of Sustainable Forest Management to a Low Emission and Resilient Development, Serbia)



274) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Serbia/Western Europe
- Climate and moisture regime: Warm temperate moist
- Dominant regional soil type: Low activity clay soils
- Duration of the project implementation: 4 years and duration of analysis set to 20 years

275) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.15.1 Detailed project analysis per activity for the Serbia Contribution of Sustainable Forest Management to a Low Emission and Resilient Development Project

5.15.1.1 Afforestation/reforestation (ILU: grassland, set aside land, and degraded land)

276) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (EX-ACT, CBP SA, AFOLU Carb, AFD-CFT, and CAT-AR) were used to analyze the afforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 22,519 tCO_2eq per year and the mean at −56,868.6 tCO_2eq per

year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for afforestation activities should be between −37,129 and −76,607 tCO_2eq per year.

277) Except for the AFOLU Carb tool, all the results generated by the tools were situated within this estimated range. This is explained by the fact that the AFOLU Carb does not account for the gain-loss and stock difference methods and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools (Table 8). The difference in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools varies: EX-ACT and CBP have a 5.35 percent difference, EX-ACT and AFD-CFT a 10 percent difference, EX-ACT and CAT-AR a 28 percent difference, CBP and AFD-CFT a 37 percent difference, CBP and CAT-AR a 54 percent difference, and AFD-CFT and CAT-AR a 17 percent difference. It is recommended to use the CBP DA to replace the grassland EFs by the corresponding values for the set aside and degraded land.

278) Based on this analysis, the four tools—CAT-AR, EX-ACT, CBP, and AFD-CFT—are suitable for afforestation GHG analysis when considering grassland as ILU. The CAT-AR, EX-ACT, and AFD-CFT for afforestation GHG analysis when considering set aside land as ILU. The EX-ACT for afforestation GHG analysis when considering degraded land as ILU.

5.15.1.2Deforestation (FLU: set aside land)

279) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP SA, and AFOLU Carb) were used to analyze deforestation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 7,684 tCO_2eq per year and the mean at −19,835 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for deforestation activities should be between 12,304 and 27,366 tCO_2eq per year.

280) All the tools provided results within this calculated range. The AFOLU Carb provides a value further away from the mean value. This is explained by the fact that the AFOLU Carb does not apply the gain-loss and stock difference methods, and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools (Table 8).

281) Based on this analysis, the difference in results between tools is minor and could be explained by the fact that different IPCC GHG accounting approaches and carbon pools apply for the tools. Using the Tier 2 methodology/coefficients instead of the Tier 1 could further decrease the difference. The difference in results between the EX-ACT, CBP, and AFOLU Carb tools varies: EX-ACT and CBP have a 33 percent difference, EX-ACT and AFOLU Carb a 36 percent difference, and CBP and AFOLU Carb a 67 percent difference.

282) Based on this analysis, the two tools—EX-ACT and AFOLU Carb—are suitable for deforestation GHG analysis when considering set aside land as the FLU.[27]

5.15.1.3 Forest management and degradation

283) Based on the sources, sinks, and SLM activities accounted for by the tools, three tools (EX-ACT, CBP, and AFOLU Carb) were used to analyze forest degradation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The difference in results between the tools is minor (8 percent).

284) Based on this analysis, the EX-ACT and CBP tools are suitable for forest management GHG analysis.

5.15.2 Project carbon balance

285) For the overall project results, the CBP and EX-ACT tools cover all project activities. The tools provide close results (0.02 tCO_2eq per hectare per year). The uncertainty level for the CBP tool equals 26 percent, while the EX-ACT results are accompanied by an uncertainty level of 39 percent.

5.16 Turkey, Sustainable land Management and Climate-Friendly Agriculture

286) The project objective is to improve sustainability of agriculture and forest land use management through the diffusion and adoption of low-carbon technologies with win-win benefits in land degradation, climate change, and biodiversity conservation and increase farm profitability and forest productivity. The project has three components:

- Component 1: Rehabilitation of Degraded Forest and Rangeland
- Component 2: Climate-Smart Agriculture
- Component 3: Enhanced enabling environment for sustainable land management

287) Based on the scope and applicability of the tools, the activities in Components 1 and 2 were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 17. The analyses focus on rehabilitating degraded forest and rangelands and improving management practices and climate-smart agriculture techniques applied across productive landscapes.

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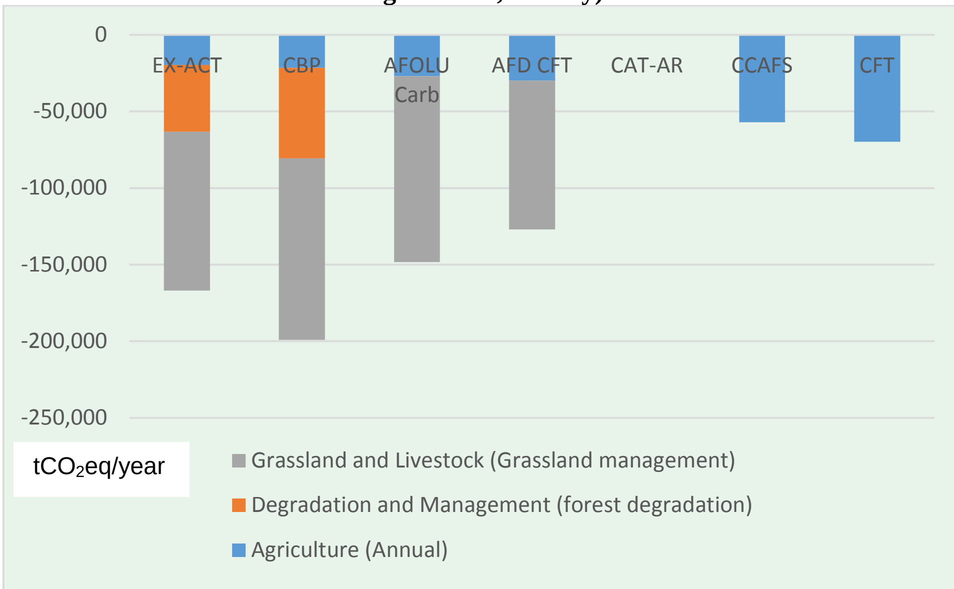
[27] The CBP DA could be used by replacing the severely degraded grassland carbon stock values with corresponding values for set aside land based on the IPCC methodology.

Figure 17: Carbon balance per component and per tool (Sustainable land Management and Climate-Friendly Agriculture, Turkey)



288) The analysis considers a set of information determined as the minimum information required to carry out a GHG analysis as follows:

- Country/continental region: Turkey/Asia continental
- Climate and moisture regime: Warm temperate dry
- Dominant regional soil type: High activity clay soils
- Duration of the project implementation: 5 years and duration of analysis set to 20 years

289) While some calculations might not require all the above information, others might also require the moisture regime and the MAT.

5.16.1 Detailed project analysis per activity for the Turkey Sustainable Land Management and Climate-Friendly Agriculture Project

5.16.1.1 Annual cropland improvement

290) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, CBP SA, AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT) were used to analyze annual cropland activities (see Table 9). The activity consists of improving the management practices of annual crops. Because the analysis was conducted following the Tier 1 methodology, the default coefficients generated by the tools were used. The standard deviation is estimated at 21,293 tCO_2eq per year and the mean at −36,711.5 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for annual cropland activities should be between −19,673 and −53,749 tCO_2eq per year.

291) Except for the CBP SA and EX-ACT tools, all the tools generated results within this estimated range. However, the results generated by the CCAFS-MOT, CFT, AFOLU Carb, and AFD-CFT tools are underestimated and do not reflect all the improved management options expressed within the project document. For instance, using the CCAFS-MOT, we assume that the entire area of annual crops will be subject to improvement by stopping the residue burning and incorporating zero tillage, while the project suggests that the annual crops improvements are improved agronomic practices, no tillage, and manure application. Further, the CCAFS-MOT and CFT tools are not based on gain-loss and stock difference methods. The estimated carbon balance using the two tools (CCAFS-MOT and CFT) was calculated separately (without and with the project scenarios) for the sake of comparison. As for the AFOLU Carb tool, it considers only two improvements, the tillage (full, reduced, and no-till) and inputs (low, medium, high with and without manure), to describe the improved management options for annual cropland.

292) The six tools have annual crops as an activity scope and can estimate the mitigation potential of this activity. However, due to the abovementioned limitations, the use of the AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT tools is not recommended. The difference in results between the EX-ACT and CBP tools is minor (8 percent). Based on this analysis, the two tools—EX-ACT and CBP—are suitable for annual crops GHG analysis when considering improved practices scenario.

5.16.1.2 Forest management and degradation

293) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and CBP SA) were used to analyze forest degradation activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients provided by the tools were used. The AFOLU Carb tool is not included within the analysis; although it considers forest protection activities, it does not consider the biomass losses that are not due to deforestation or illegal logging. The difference in results between the EX-ACT and CBP tools is high (30 percent). Based on this analysis, the EX-ACT and CBP tools are suitable for forest management GHG analysis.

5.16.1.3 Grassland management

294) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, CBP SA, AFOLU Carb, and AFD-CFT) were used to analyze grassland management activities (see Table 9). Because the analysis was conducted following the Tier 1 methodology, the default coefficients provided by the tools were used. The mean and standard deviation are respectively −109,991.5 tCO_2eq per year and 11,669 tCO_2eq per year with the 95 percent confidence interval of the mean between −98,555 and −121,427 tCO_2eq per year.

295) All the results generated by the tools were situated within this estimated range. The differences in the results provided by the tools are mainly due to the different EFs and carbon stock change values associated with the Tier 1 methodology. The AFD-CFT tool, for example, calculated the default soil carbon stock changes based on a set of IPCC questions, whereas the AFOLU Carb provided estimated values for relative stock change factors instead.

296) The differences in results between the tools varies: EX-ACT and CBP have a 13 percent difference, EX-ACT and AFD-CFT a 6 percent difference, EX-ACT and AFOLU Carb a 15 percent difference, CBP and AFD-CFT a 19 percent difference, CBP and AFOLU Carb a 3 percent difference, and AFD-CFT and AFOLU Carb a 22 percent difference.

297) Based on this analysis, the four tools—EX-ACT, CBP, AFOLU Carb, and AFD-CFT—are suitable for grassland management GHG analysis with the Tier 1 methodology.[28]

5.16.2 Project carbon balance

298) For the overall project results, the CBP and EX-ACT cover all project activities. The tools generated close results (0.3 tCO_2eq per hectare per year) with an uncertainty level estimated at 19 percent for the CBP tool and 47 percent for the EX-ACT tool.

5.17 Chile, Sustainable Land Management Project

299) The project's Global Environment Objective (GEO) is to develop a national framework for SLM to combat land degradation, mainstream biodiversity into national policies, and protect forest carbon assets. The main project beneficiaries will be (a) the rural poor, including indigenous communities, whose lands are degraded or threatened and can benefit from improvements in soil conservation and improved sustainability of production systems; (b) private sector producers; (c) civil society benefitting from an improved landscape that incorporates water, soil, biodiversity, carbon, and other intangibles as values; and (d) native biodiversity in global priority hotspots.

300) The executing agency is the Chilean National Forestry Corporation (CONAF), which will also manage procurement and share responsibility for financial management. The land area targeted, where SLM practices will be applied to reduce land degradation, is about 100,000 ha. This includes 25,000 ha of new sites managed outside protected areas, 3,464 ha of restored/afforested areas, and 57,250 ha of forest areas brought under forest management plans.

301) The National SLM framework approach will be piloted in four geographic regions that are globally and nationally recognized as priority areas for conservation, including: (a) the

[28] The specific value suitable for organic carbon present in soils should be provided for the AFOLU Carb.

Central Andean Dry Puna, (b) the Chilean Mattorral, (c) the Winter Rainfall Forest - Valdivian Temperate Rainforest, and (d) the Patagonian Andes Nothofagus forests and steppe. A total of five strategic pilot areas, were identified during preparation, one in each of the ecological regions, except for the Chilean Mattoral region, which has two sites. SLM will be carried out on intervention area through subprojects on individual or community landholdings in cooperation and agreement with producers in the five pilot areas.

5.17.1 Key project activities acting on GHG

302) Based on the scope and applicability of the tools, afforestation, forest management, and grassland management activities were assessed on a total area of 123,095 ha. The results of the carbon balance obtained by the tools are summarized in Figure 18. The project area is subject to the improvement of land management practices, forest restoration and afforestation, and forest areas brought under forest management plans. The project targets four regions in Chile.

5.17.1.1 Aysen Cohaique site

303) Without the project implementation, (a) 6 ha of degraded land would remain degraded and none of the afforestation activities would take place; (b) 130 ha of subtropical humid forest would remain in a state like the initial state of degradation, that is, moderately degraded; and (c) 4 ha of grassland would remain moderately degraded.

304) With the project implementation, the afforestation/restoration activities will take place and the degraded area will be replaced with 6 ha of temperate continental forest, and 130 ha of the woodland will be improved from 40 percent biomass lost to 10 percent biomass lost. The forest management scenario is accompanied by an improvement of grassland management practices on 4 ha. The forest characteristics in the intervention areas are summarized in Tables 16 and 17.

Table 16: Temperate continental forest carbon sequestration potential within the biomass

Growth rates for systems up to 20 years (tC/ha/year)		**Growth rates for systems after 20 years (tC/ha/year)**	
Above-ground	**Below-ground**	**Above-ground**	**Below-ground**
5.25	1.52	5.25	1.52

Table 17: Woodland forest carbon sequestration potential within the biomass and dead wood

Above-ground (tC/ha)	**Below-ground (tC/ha)**	**Dead wood (tC/ha)**
115.6	33.5	8.3

5.17.1.2 Combarbalá site

305) Without the project implementation, (a) 30 ha of degraded grassland would remain degraded and none of the afforestation activities would take place, (b) 60 ha of severely degraded grassland would remain severely degraded, and (c) 130 ha of subtropical steppe forest would pass from 40 percent biomass lost to 60 percent biomass lost.

306) With the project implementation, the afforestation/restoration activities will take place, the degraded grassland area will be replaced by 30 ha of subtropical steppe forest, and 200 ha of subtropical steppe forest will pass from 40 percent biomass lost to 20 percent biomass lost. The forest management scenario is accompanied by an improvement of grassland management practices on 60 ha. The forest characteristics in the intervention areas are summarized in Tables 18 and 19.

Table 18: Subtropical steppe forest carbon sequestration potential within the biomass

Growth rates for systems up to 20 years (tC/ha/year)		Growth rates for systems after 20 years (tC/ha/year)	
Above-ground	**Below-ground**	**Above-ground**	**Below-ground**
1.9	0.56	1.9	0.56

Table 19: Subtropical steppe forest carbon sequestration within the biomass

Above-ground (tC/ha)	Below-ground (tC/ha)
37.6	10.9

5.17.1.3 Ohiggins - Litueche site

307) Without the project implementation, (a) 125 ha of degraded land would remain degraded and none of the afforestation activities would take place, (b) 20 ha of moderately degraded pasture would remain the same as compared to the initial state of degradation, and (c) 550 ha of subtropical dry forest would pass from 60 percent biomass lost to 80 percent biomass lost.

308) With the project implementation, the afforestation/restoration activities will take place and the degraded land area will be replaced with 30 ha of broadleaved forest, and 550 ha of subtropical dry forest will be improved from 60 percent biomass lost to 40 percent biomass lost. This improved forest management scenario is accompanied by an improvement of grassland management practices on 20 ha. The forest characteristics in the intervention areas are summarized in Tables 20 and 21.

Table 20: Broadleaved forest carbon sequestration potential within the biomass

Growth rates for systems up to 20 years (tC/ha/year)		Growth rates for systems after 20 years (tC/ha/year)	
Above-ground	**Below-ground**	**Above-ground**	**Below-ground**
1.9	0.56	1.9	0.56

Table 21: Subtropical dry forest carbon sequestration within the biomass

Above-ground (tC/ha)	Below-ground (tC/ha)
57.8	16.8

5.17.1.4 Araucania - Los Sauces (previously purto saaverda)

309) Without the project implementation, none of the afforestation will take place, and the 235-ha subject to restoration activities will remain degraded land. With the project

implementation, the afforestation/restoration activities will take place, and thus the degraded land area will be replaced with 235 ha of subtropical humid forest. The forest characteristics are summarized in Tables 22.

Table 22: Subtropical humid forest carbon sequestration potential within the biomass

Growth rates for systems up to 20 years (tC/ha/year)		Growth rates for systems after 20 years (tC/ha/year)	
Above-ground	**Below-ground**	**Above-ground**	**Below-ground**
5.3	1.5	5.3	1.5

310) As per the overall project activities, Tables 23 to 25 summarize the main rehabilitated forestlands and grasslands.

Table 23: Afforestation/reforestation scenarios within the project's three sites

Sites	Type of vegetation that will be afforested	Previous land use	Area that will be afforested (ha)
Aysen Cohaique	Subtropical humid forest	Degraded land	6
Combarbalá	Subtropical steppe	Grassland	30
Ohiggins - Litueche	Subtropical dry forest	Degraded land	125
Araucania - Los Sauces	Subtropical humid forest	Degraded land	235
		Total area (ha)	396

Table 24: Forestry rehabilitation scenarios within the project's three sites

Sites		Degradation level of the vegetation (percent of biomass lost)			Area (ha)
	Type of vegetation	Initial state	Without project	With project	
Aysen Cohaique	Subtropical humid forest	40	40	10	130
Combarbalá	Subtropical steppe	40	60	30	220
Ohiggins - Litueche	Subtropical dry forest	60	80	40	550
				Total area (ha)	900

Table 25: Grassland management scenarios within the project's three sites

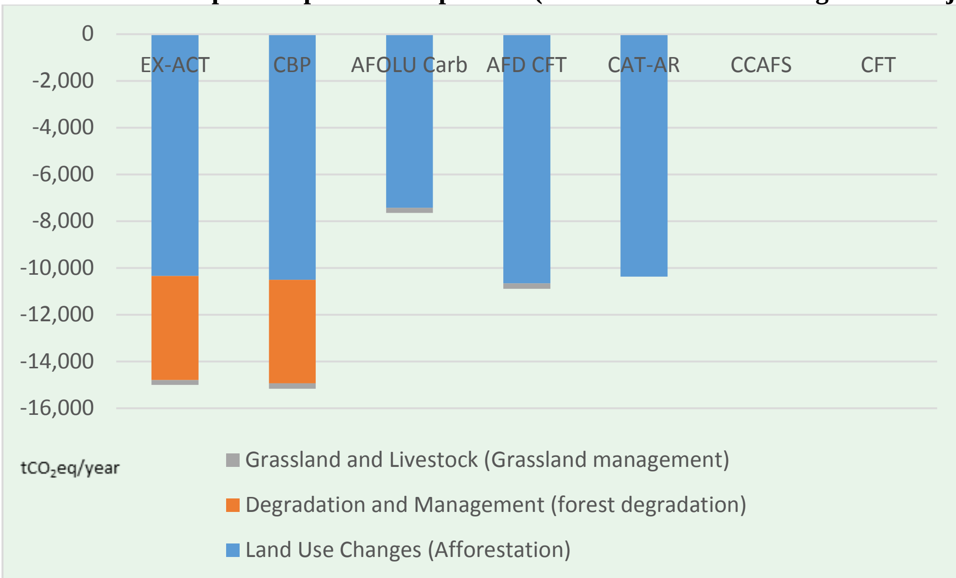
Type of vegetation	Degradation level of the vegetation			Area (ha)
	Initial state	Without project	With project	Start-Without-With
Aysen Cohaique	Moderate	Moderate	Improved with inputs	4
Combarbalá	Severe	Severe	Improved without inputs	60
Ohiggins - Litueche	Moderate	Moderate	Improved without inputs	20
			Total area (ha)	84

The average above-ground biomass of the grassland dominant species is 4.7 tC per ha.

5.17.2 Detailed project analysis per activity for the Chile Sustainable Land Management and Climate-Friendly Agriculture Project

311) Based on the scope and applicability of the tools, the activities were assessed. The results of the carbon balance obtained by the tools are summarized in Figure 18.

Figure 18: Carbon balance per component and per tool (Sustainable Land Management Project, Chile)



5.17.2.1 Afforestation activities (ILU: degraded land and grassland)

312) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (CAT-AR, CBP SA, AFD-CFT, AFOLU Carb, and EX-ACT) were used to analyze afforestation activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients were replaced with country-/region-specific coefficients. The mean and standard deviation are respectively −9,864.2 tCO_2eq per year and 1,366 tCO_2eq per year, with 95 percent confidence interval between –8,666 and –11,062 tCO_2eq per year.

313) Except for the AFOLU Carb, all the results generated by the tools were situated within this range. This is explained by the fact that the AFOLU Carb does not apply the gain-loss and stock difference methods (Table 8), and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools. The difference in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools is minor: EX-ACT and CBP have a 1.5 percent difference, EX-ACT and AFD-CFT a 3 percent difference, EX-ACT and CAT-AR a 0.34 percent difference, CBP and AFD-CFT a 1.4 percent difference, CBP and CAT-AR a 1.4 percent difference, and AFD-CFT and CAT-AR a 2 percent difference.

314) Based on this analysis, the four tools—CAT-AR, CBP, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering grassland as ILUs.[29] While the EX-ACT is suitable when considering degraded land as the ILU.

[29] The use of CBP DA assessment is recommended.

5.17.2.2 Grassland management

315) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, AFOLU Carb, CBP SA, and EX-ACT) were used to analyze grassland management activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients were replaced with country-/region-specific coefficients. The standard deviation is estimated at 13.6 tCO_2eq per year and the mean at −220.25 tCO_2eq per year with a significance level of 0.05 (CI = 95 percent, 1.960 standard error of the mean). Therefore, the range of results for grassland management activities should be between −208 and −233 tCO_2eq per year.

316) A minor difference was observed within the results. The difference in the results generated by the tools was mainly due to the use of different IPCC GHG accounting approaches and carbon pools (Table 8). For example, the AFD-CFT tool calculates the default soil carbon stock changes based on a set of IPCC questions, whereas the AFOLU Carb provides estimated values for relative stock change factors.

317) The difference in results between the tools are minor: EX-ACT and CBP have a 7 percent difference, EX-ACT and AFD-CFT a 11 percent difference, EX-ACT and AFOLU Carb a 6 percent difference, CBP and AFD-CFT a 3 percent difference, CBP and AFOLU Carb a 0.9 percent difference, and AFD-CFT and AFOLU Carb a 4 percent difference.

318) Based on this analysis, the four tools—EX-ACT, CBP, AFD-CFT, and AFOLU Carb—are suitable for grassland management GHG analysis using a Tier 2 methodology.[30]

5.17.2.3 Forest management and degradation

319) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and the CBP SA) were used to analyze forest management activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients were replaced with country-/region-specific coefficients. The AFOLU Carb tool is not considered within the analysis; although it considers forest protection activities, it does not consider the biomass losses that are not due to deforestation or illegal logging. On the impact of forest management and degradation, only the CBP and EX-ACT tools allow for the use of Tier 2 coefficients to describe the states of degradation. The difference in results between the EX-ACT and CBP tools is minor (0.65 percent). Based on this analysis, the EX-ACT and CBP tools are suitable for forest management GHG analysis.

[30] The specific values for the soil carbon sequestration were not modified, which explains the small variability within the results.

5.17.3 Project carbon balance

320) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and CBP) were capable of analyzing the overall project activities (see Table 9). The following paragraphs focus on a detailed description of the results obtained using tools that allow an estimate of the overall project activities results in terms of GHG emissions.

5.17.3.1 EX-ACT analysis

321) The project carbon balance presented in this section was assessed with the EX-ACT tool to provide a detailed GHG results distribution between all activities affected by the project. It provides results both for the 20 years duration of a typical project GHG appraisal and per year. The results per ha are also included.

322) **Baseline EX-ACT Assumptions.** The EX-ACT analysis takes into account the specific environmental features (soil and climate types) of each case study. Soil and climate information is needed to determine the coefficients used in the analysis. Average climates considered in the analysis are *warm temperate*. The moisture regime was classified as *dry*, and the dominant soil type was classified as *high activity clay*. The *implementation phase* of the SLM project was specified as 2 years, followed by an estimated capitalization phase of 18 years.

323) According to the EX-ACT calculation, the SLM project could have a climate mitigation potential of roughly −300 ktCO_2eq reduced/fixed on 20 years (direct impact), primarily through afforestation/reforestation activities (−206 ktCO_2eq) and rehabilitation of degraded forests (−90 ktCO_2eq). This project could fix around 13 tons of CO_2eq per hectare per year. The uncertainty level with the EX-ACT tool is 20 percent.

5.17.3.2 CBP analysis

324) The project's carbon balance provided in this section was analyzed with the CBP tool to provide a detailed GHG results distribution between all activities affected by the project. It provides results for the six years duration of a typical project GHG implementation phase and per year.

325) **Baseline CBP Assumptions.** The CBP analysis considers specific environmental features for the land use climate zones of each case study. The coefficients used in the analysis were completed with the Tier 2 values. Because the CBP tool does not consider degraded land as a land use category, we consider the ILU as annual cropland with a carbon stock of 1 tC per ha and soil carbon stock is set to 12.5 tC per ha.

326) The CBP tool allowed for simultaneous calculations of emissions generated by activities (afforestation activities and the forest management and degradation activities) and emissions generated by the grassland management.

327) According to CBP calculations, the SLM project could have a mitigation impact of roughly −300 tCO_2eq reduced/fixed on 20 years (direct impact) or 10.98 tCO_2eq per year per hectare, mostly through afforestation/reforestation activities and the rehabilitation of degraded forests. The uncertainty level with the CBP is 19 percent.

5.17.4 Conclusion

328) The SLM project aims to provide a GHG mitigation impact ranging between −15,010 and −15,163.1 tCO_2eq per year on 1,380 ha (an average of −10.88 and 10.99 tCO_2eq per year).

329) On the impact of afforestation and forest and grassland management, only the CBP and EX-ACT tools generated results using Tier 2 coefficients, both to characterize the type of vegetation and the reduction of standing stock on remaining forests.

330) At a global level, both the CBP and EX-ACT tools provided relatively close results, with roughly a 1.01 percent difference. The EX-ACT had an uncertainty level of 20 percent as compared to the CBP's 26 percent uncertainty level.

5.18 Tunisia, Second Natural Resources Management Project

331) The project's GEO is to improve the living conditions of rural communities in the project areas in terms of access to basic infrastructure and services, sustainably increase income, and improve natural resource management practices by fostering an integrated approach to community-based development. There are three components to the project.

- **Component 1: Support to Participatory Development Plan (PDP) investments.** This component will contribute to the project development objective by supporting the financing of investments within the PDPs framework, which reflects the priority needs of local communities in the project target areas.
- **Component 2: Support to the development of treated wastewater use for agriculture.** The objective of this component is to support the National Program for Wastewater Reuse through the transfer of treated wastewater from the Greater Tunis area toward the interior of the country (south of the Tunisian Dorsal). In these areas, demand for water is high and treated wastewater will help increase yields on agricultural land, reduce fluctuations in agricultural production, and enhance adaptation to climate variability and change.
- **Component 3: Institutional strengthening and awareness raising.** The objective of this component is to support the mainstreaming of the Integrated Participatory Approach (IPA) in rural development in the three governorates of Jendouba, Kasserine, and Medenine through institutional strengthening and capacity building of target groups involved in project implementation. The component will also support

the implementation of a monitoring and evaluation (M&E) system for project activities and for safeguards and communication and sensitization on SLM and environmental issues.

5.18.1 Key project activities acting on GHG

332) Based on the scope and applicability of the tools, crops management, grassland management, livestock, and creation of rural tracks and irrigation infrastructures activities were assessed on a total area of 21,877.5 ha. The implementation phase is seven years. The project area is subject to the improvement of land management practices, forest restoration and afforestation, and forest areas brought under forest management plans. The project targets three regions in Tunisia.

5.18.1.1 Médenine sites

Afforestation activities

333) The project aims at developing beekeeping activities by distributing more than 20,000 hives and combating desertification by planting honey-bearing trees mainly *Eucalyptus camaldulensis*. Without the project implementation, 53 ha of afforestation will take place. With the project implementation, the afforestation/restoration activities will take place on 90 ha. Thus, the degraded land area will be replaced with 47 ha of forest. The forest characteristics are summarized in Table 26.

Table 26*: Afforestation activities PRGN2 project-species above-ground net volume growth*

Species	Biomass expansion factor[31]	Wood density[32] t dm/m^3	Above-ground net volume growth[33] m^3/ha/year	Above-ground net volume growth t dm/ha/year
Eucalyptus camaldulensis	1.30	0.40	22.50	11.7

Grassland management

334) About 750 ha of grassland in Médenine sites are described as severely degraded. Without the project implementation, no further improvements are observed as compared to the initial state of degradation. With the project implementation, 750 ha of grassland would be subject to improved management practices without input use. The main dominant species is Sulla (*Hedysarum coronarium*). The grassland management is summarized in Table 27.

[31] Temperate Conifers: Spruce-fir, see IPCC GPG-LULUCF Table 3A.1.10.
[32] See IPCC 2006 Guidelines, V4. Table 4.13.
[33] See IPCC 2006 Guidelines, V4. Table 4.11A.

Table 27: Grassland management activities, Médenine

Sites	Grazing species	Area (ha)	State of the grassland at project start	Future state of the grassland	Above-ground biomass (tdm/ha)[34]
C.R.D.A Médenine	Sulla	750	Severely degraded	Improved without inputs	6.59

Annual crops

335) With the project implementation, 3,051 ha of annual crops will be managed, improved, and developed. The annual cropland activities target both annual full field and greenhouse crops, both irrigated and non-irrigated crops. About 3,750 ha of annual crops are managed with improved agricultural management practices, improved seeds and varieties, crop rotation, nutrient management, and no tillage residue retention. No improved management practices would be carried out without the project implementation and the crop residues would continue to be burnt. The targeted areas are as follows:

Table 28: Annual crops development and improvement activities, Médenine

Type of annual vegetation system	Area (ha)	Previous Land Use	Practices
Development of annual crops full field	Irrigated	400 ha	Degraded land
	Non-irrigated	200 ha legumes	Set aside
		200 ha cereals: wheat and barley	Set aside
Development of annual crops in greenhouses	Tomato	1.5 ha	Degraded land
	Pepper	1 ha	Degraded land
	Cucumber	1.5 ha	Degraded land
	Melon	0.5 ha	Degraded land
Improved existing annual crops (tomato, pepper, cucumber, and melon)	Irrigated	1,250 ha	Annual crops
	Non-irrigated	1,000 ha	Annual crops

Perennial crops

336) To improve the livelihoods of local households, the project plans on planting tree crops on a total area of 10,200 ha of set aside land through an agroforestry approach in Médenine sites. In addition, the project aims to improve the management practices on 1,530 ha of land (1,500 ha of olives and 30 ha of orchards) through improved nutrient management. Without the project implementation, no plantation and improvement practices would take place. The perennial trees characteristics are summarized in Table 29.

[34] *Diversités phénotypique et moléculaire des micro-symbiotes du Sulla du nord (Hédysarum Coronarium L.) et sélection de souches rhizobiales efficientes*". SD Fitouri.

Table 29: Growth rates for olives and orchards up to 20 years (tC/ha/year)

Perennial trees	Growth rates for perennial systems (tC/ha/year)	
	Above-ground	Below-ground
Olives (Proietti et al. 2016)	3.33	0.87
Orchards (Scandellari et al. 2017)	2.45	1.10

5.18.1.2 C.R.D.A Kasserine

Grassland management development

337) The development of new pasture areas within private courses is one of the targeted project activities. With the project implementation, 442 ha of alfa (*Stipa tenacissima*), wormwood *(Artemisia vulgaris),* and rosemary (*Rosmarinus officinali*s) species would be planted on set aside land. The assumption is made that those species have on average an above-ground biomass similar to the Sulla species, 1.9 tC per ha.

Perennial crops development and improvements

338) To improve the livelihoods of local households, the project plans on planting olive trees (2,200 ha) and orchards (95 ha) on a total area of 2,295 ha of set aside land through an agroforestry approach. Without the project implementation, no trees will be planted. The weighted average above-ground biomass growth is 3.24 tC per ha per year and 0.89 tC per ha per year for the below-ground biomass.

5.18.1.3 C.R.D.A Jendouba

Grassland management and development

339) The project aims to develop new pasture areas in both forest and private courses. With the project implementation, 40 ha of sulla (*Hedysarum coronarium*) species would be planted on set aside land (forest courses) and 2,000 ha on private courses on set aside land and degraded land. Without the project implementation, no new pasture area would be developed. The default values are used to describe the grassland species characteristics in warm temperate region.[35]

Perennial crops development and improvement

[35] See IPCC 2006 Guidelines, Chapter 6 Grassland.

340) The project intends to plant olive trees (1,500 ha) and grenadier trees (26 ha) on a total area of 1,526 ha of set aside land. Without the project implementation, no trees will be planted.

Livestock activities: C.R.D.A Médenine, Kasserine, and Jendouba

341) With the project implementation, 164,103 heads of sheep and goats would be distributed in the three targeted areas. The project also targets the improvement of the breeding practices and the enhancement of veterinary monitoring. The livestock activities are summarized in Table 30.

Table 30: Livestock management activities for the three sites

Type of livestock	C.R.D.A Médenine		C.R.D.A Kasserine		C.R.D.A Jendouba		Total
	Start	Future with project	Start	Future with project	Start	Future with project	With the project
	Number of heads		Number of heads		Number of heads		
Sheep	45,000	51,700	40,320	42,420	—	—	94,120
Goats	45,000	51,750	17,280	18,180	30	53	69,983
Improvements breeding practices and feeding practices							
Sheep	60 percent	100 percent	—	—	60 percent	100 percent	

Inputs and investments: C.R.D.A Médenine, Kasserine, and Jendouba

342) With the project implementation, a total area of 2,976 ha will be rehabilitated through improved water management practices and will benefit from the installation of 2,894 ha of trickle irrigation, a sprinkler system on 82 ha and the installation of 40 irrigation basins equivalent to 62,400 m^2 of agricultural building (concrete). Without the project implementation, no additional irrigation system would be installed. With the project implementation, 167.4 km of rural roads for medium traffic (asphalt) would be rehabilitated.

Table 31: Infrastructures development PRNG2 project

Activities	Achievements			Type of irrigation infrastructure installed (sprinkler, drip ...)	Total
	C.R.D.A Médenine	C.R.D.A Jendouba	C.R.D.A Kasserine		
Irrigated areas	11 ha	187 ha	2,696 ha	Trickle	2,894 ha
	57 ha	25 ha	—	Solid roll sprinkle	82 ha
	Private equipment by water basins: 40 Units	—	—	Irrigation basin (30 m3)	1,200 m^3
Creation of rural tracks	51 km	61.8 km	54.6 km	Asphalting tracks	167.4 km

Fertilizer use

343) In contrast to the project activities, it was identified that fertilizers would be applied to achieve the desired productivity targets. Thus, the yearly quantities used, with the project implementation, are 70,172.5 kg of Nitrogen (N), 185,985 kg of phosphorus (P_2O_5), and 173,470 kg of potassium (K_2O). The manure application is 47,592.5 tons. Without the project implementation, no fertilizers would be used (Table 33).

5.18.2 Detailed project analysis per activity for the Tunisia GEF Second Natural Resources Management Project

344) Based on the scope and applicability of the tools, the activities were assessed. The results of the carbon balance obtained by the tools are summarized Figure 19.

Figure 19: Carbon balance per component and per tool (Second Natural Resources Management, Tunisia)

5.18.2.1 Afforestation activities (ILU: degraded land)

345) Based on the sources, sinks, and SLM activities accounted for by the tools, five tools (CAT-AR, CBP DA, AFD-CFT, AFOLU Carb, and EX-ACT) were used to analyze afforestation activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients were replaced with country-/region-specific coefficients. The mean and standard deviation are respectively −631.6 tCO_2eq per year and 66 tCO_2eq per year. The estimated 95 percent confidence interval of the mean is between −573 and −689 tCO_2eq/year.

346) Except for the AFOLU Carb, all the results generated by the tools were situated within this range. This is explained by the fact that the AFOLU tool does not apply the gain-loss and stock difference methods (Table 8) and therefore, does not compute emissions or removals as the change over time of carbon stocks for the different pools. The difference in results between the EX-ACT, CBP, AFD-CFT, and CAT-AR tools is minor: EX-ACT and CBP have a 2.4 percent difference, EX-ACT and AFD-CFT a 0.8 percent difference, EX-ACT and CAT-AR a 2.9 percent difference, CBP and AFD-CFT a 3 percent difference, CBP and CAT-AR a 4 percent difference, and AFD-CFT and CAT-AR a 1 percent difference.

347) Based on this analysis, the four tools—CAT-AR, CBP, AFD-CFT, and EX-ACT—are suitable for afforestation GHG analysis when considering degraded land as ILU (degraded land).[36]

5.18.2.2 Annuals cropland development and improvement

348) Based on the sources, sinks, and SLM activities accounted for by the tools, six tools (EX-ACT, CBP DA, AFD-CFT, AFOLU Carb, CCAFS-MOT, and CFT) were used to analyze annual cropland activities. The activity consists of developing annual crops in degraded and set aside areas through improved management practices. The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients were replaced with country or region-specific coefficients. The mean and standard deviation are respectively 833 tCO_2eq per year and 565.6 tCO_2eq per year, and the 95 percent confidence interval of the mean is between −2,283 and −3,618 tCO_2eq per year.

349) Other than the CCAFS-MOT and AFOLU Carb tools, all the results provided by the tools were situated within this range. This is explained by the fact that the CCAFS-MOT tool does not consider all the land use changes (only forest to grassland, and arable or grassland to arable or grassland) and has limited management options. Similarly, the AFOLU Carb does not consider all the management practices (only tillage and inputs management) and land use changes.

[36] The use of CBP DA assessment is recommended.

350) **For annuals crop development:** The difference in results between the EX-ACT, CBP, and AFD-CFT tools for annual cropland development are as follows: EX-ACT and CBP have a 5 percent difference, EX-ACT and AFD-CFT a 12 percent difference, and CBP and AFD-CFT a 14 percent difference. The difference could be explained by the fact that the AFD-CFT tool does not consider degraded land as ILU. For the AFD-CFT, the set aside land was considered instead to be *Cropland - Set aside (<20 years), Temperate/Boreal/Tropical, moist/wet*.

351) **For annuals crop improvement:** The difference in results between the EX-ACT and CBP tools is 5 percent.

352) Based on this analysis, the three tools—EX-ACT, CBP, and AFD-CFT—are suitable for annual crops GHG analysis when considering management improvements scenarios, while, the two tools—EX-ACT and CBP—are suitable for annual crops GHG analysis when considering improved practices scenarios.

5.18.2.3 Perennial cropland development (ILU: set aside)

353) Based on the sources, sinks, and SLM activities accounted for by the tools—three tools (EX-ACT, CBP DA, and AFD-CFT) were used to analyze perennial activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, default coefficients provided by the tools were replaced to describe the baseline and with project above-ground growth rate (tC per ha per year) both to characterize the type of vegetation and the improvement of the biomass growth. The mean and standard deviation are respectively at −180,820 tCO_2eq per year and 12,789 tCO_2eq per year. The 95 percent confidence interval of the mean is between −166,348 and −195,293 tCO_2eq per year.

354) All the results generated by the tools were situated within this range. The EX-ACT, CBP, and CAT-AR tools provided similar results: EX-ACT and CBP DA have a 7 percent difference, EX-ACT and AFD-CFT a 14 percent difference, and CBP and AFD-CFT a 6 percent difference.

355) Based on this analysis, the three tools—EX-ACT, CBP DA, and AFD-CFT—are suitable for GHG analysis of perennial cropland development when considering set aside land as the ILU and when using Tier 2 methodology.

5.18.2.4 Grassland management and development

356) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, AFOLU Carb, CBP SA, and AFD-CFT) were used to analyze grassland management and grassland development activities (see Table 9). The activity analysis was conducted following the Tier 2 methodology; therefore, the default coefficients were replaced with country-/region-specific coefficients. The mean and standard deviation are

respectively −220.25 tCO_2eq per year and 7,134 tCO_2eq per year, with the 95 percent confidence interval of the mean lying between −6,144 and −20,127 tCO_2eq per year.

357) All the results provided by the tools were situated within this range, except for the AFOLU Carb. The difference in results between the EX-ACT, CBP, and AFD-CFT tools is minor: EX-ACT and CBP have a 3 percent difference, EX-ACT and AFD-CFT a 6 percent difference, and CBP and AFD-CFT a 3 percent difference.

358) Based on this analysis, the three tools—EX-ACT, CBP, and AFD-CFT—are suitable for GHG analysis of grassland management and development using Tier 2 methodology.

5.18.2.5 Livestock

359) Based on the sources, sinks, and SLM activities accounted for by the tools, four tools (EX-ACT, CBP, CCAFS-MOT, and CFT) were used to analyze livestock management activities (see Table 9). However only two tools, EX-ACT and CBP DA, were able to estimate the total carbon balance as the analysis considered Tier 2 values. The AFOLU Carb tool does not consider the Tier 2 values for livestock and therefore, the result is zero; no difference before and after the project. The CFT does not allow the user to enter Tier 2 values, and the calculation to compare two situations is not possible. However, both the CFT and CCAFS-MOT tools provide the user with options on mitigation options including feeding practices, manure management, and energy consumption.

360) The difference in results between the EX-ACT and CBP DA tools is minor (0.84 percent). Based on this analysis, the two tools—EX-ACT and CBP—are suitable for livestock GHG analysis using the Tier 2 methodology.

5.18.2.6 Inputs and investments (fertilizers, irrigation, and agricultural buildings)

361) Based on the sources, sinks, and SLM activities accounted for by the tools, two tools (EX-ACT and AFD-CFT) were used to analyze energy consumption (see Table 9). The activity analysis was conducted following the Tier 1 methodology; therefore, default coefficients provided by the tools were used. There was a minor observable difference between the results. The AFD-CFT does not consider irrigation infrastructure and fertilizer use. Thus, the EX-ACT tool was the most suitable for GHG analysis of the fertilizers, irrigation, and agricultural buildings, while the AFD-CFT estimated only emissions related to agricultural building construction.

5.18.3 Project carbon balance

362) Based on the sources, sinks, and SLM activities accounted for by the tools, only one tool (EX-ACT) covered the appropriate areas of GHG appraisal (see Table 9). The following paragraphs focus on a detailed description of the results obtained using tools that allow an estimate of the overall project activities' results in terms of GHG emissions.

5.18.3.1 EX-ACT analysis

363) The project carbon balance provided in this section was analyzed with the EX-ACT tool to provide a detailed GHG results distribution between all activities affected by the project. It provides results both for the whole 20 years duration of a usual project GHG appraisal and per year. Results per ha are provided in the following paragraphs.

364) **Baseline EX-ACT Assumptions:** The EX-ACT analysis considers the specific environmental features (soil and climate types) of each case study. Soil and climate information are needed to determine the coefficients used in the analysis. Average climates considered in the analysis are *warm temperate*. The moisture regime was classified as *dry*, and the dominant soil type was classified as *high activity clay*. The *implementation phase* of second Natural Resources Management Project was specified as 7 years followed by an estimated capitalization phase of 13 years.

365) The Sustainable Land Management Project could have a climate mitigation impact of roughly −4,100 ktCO_2eq reduced/fixed on 20 years (direct impact) mostly through perennials development activities (−3,800 ktCO_2eq) and rehabilitation and development of grassland (−300 ktCO_2eq). This project could fix around 9.5 tons of CO_2eq per year per hectare. The uncertainty level with the EX-ACT tool is 21 percent.

5.18.4 Conclusion

366) The Second Natural Resources Management project aims to provide a GHG mitigation impact of −206,770 tCO_2eq per year on 21,877.5 hectares. The project, which targets crops management, grassland management, livestock, and creation of rural tracks and irrigation infrastructures activities, is within the range of a series of SLM projects. At a global level, only the EX-ACT tool covers all the project activities, coming in at an uncertainty level of about 21.2 percent. Tables 32 to 35 summarize the project activities.

Table 32: Afforestation activities

Type of forest vegetation	ILU (pre-project)	Afforested area	
		Without project (ha)	With project (ha)
Eucalyptus gomfocephala and Eucalyptus camaldulensis	Degraded land	53	90

Table 33: Grassland management (C.R.D.A Médenine)

Sites	Grazing species	Area (ha)	State of the grassland at project start	Future state of the grassland
C.R.D.A Médenine	Sulla	750	Severely degraded	Improved without inputs

Table 34: Annuals crops management and development

<table>
<tr><th colspan="2">Type of annual vegetation system</th><th>Area (ha)</th><th>Previous Land Use</th><th>Practices</th><th>Average amount of fertilizer and pesticide used (kg / ha)</th></tr>
<tr><td rowspan="3">Annual crops full field</td><td>Irrigated</td><td>400 ha</td><td>Degraded land</td><td>Zero tillage + nutrient management</td><td>40 t/ha of manure + 50 kg/ha of N + 120 kg/ha of P_2O_5 + 120 kg/ha of K_2O</td></tr>
<tr><td rowspan="2">Not irrigated</td><td>200 ha legumes</td><td>Set aside</td><td>Zero tillage + nutrient management</td><td>1 ton per ha of manure</td></tr>
<tr><td>200 ha cereals: wheat and barley</td><td>Set aside</td><td>Zero tillage</td><td>—</td></tr>
<tr><td rowspan="4">Annual crops in greenhouses</td><td>Tomato</td><td>1.5 ha</td><td>Degraded land</td><td>Improved seeds and varieties + nutrient management</td><td>40 t/ha of manure + 50 kg/ha of N + 120 kg/ha of P_2O_5 + 120 kg/ha of K_2O</td></tr>
<tr><td>Pepper</td><td>1 ha</td><td>Degraded land</td><td>Improved seeds and varieties + nutrient management</td><td>25 t/ha of manure + 40 kg/ha of N + 110 kg/ha of P_2O_5 + 100 kg/ha of K_2O</td></tr>
<tr><td>Cucumber</td><td>1.5 ha</td><td>Degraded land</td><td>Improved seeds and varieties + nutrient management</td><td>30 t/ha of manure + 30 kg/ha of N + 100 kg/ha of P_2O_5 + 90 kg/ha of K_2O</td></tr>
<tr><td>Melon</td><td>0.5 ha</td><td>Degraded land</td><td>Improved seeds and varieties + nutrient management</td><td>25 t/ha of manure + 50 kg/ha of N + 90 kg/ha of P_2O_5 + 90 kg/ha of K_2O</td></tr>
<tr><td rowspan="2">Annual crops existing and improved (tomato, pepper, cucumber and melon)</td><td>Irrigated</td><td>1,250 ha</td><td>Annual crops</td><td>Improved seeds and varieties + crop rotation + nutrient management</td><td>25 t/ha of manure + 40 kg/ha of N + 110 kg/ha of P_2O_5 + 100 kg / ha of K_2O</td></tr>
<tr><td>Not irrigated</td><td>1,000 ha</td><td>Annual crops</td><td>No tillage + improved agronomic practices</td><td>—</td></tr>
<tr><td colspan="2">Total area</td><td>3,051 ha</td><td>Total Fertilizers</td><td colspan="2">47,592.5 t/ha of manure
70,172.5 kg/ha of N
185,985 kg/ha of P_2O_5
173,470 kg/ha of K_2O</td></tr>
</table>

Table 35: Perennial crops management and development

<table>
<tr><th>Sites</th><th colspan="2">Type of perennial vegetation system</th><th>Previous Land Use</th><th>Area (ha)</th></tr>
<tr><td rowspan="4">C.R.D.A Médenine</td><td rowspan="2">Improved tree crops</td><td>Olives</td><td>—</td><td>1,500</td></tr>
<tr><td>Grenadiers</td><td>—</td><td>30</td></tr>
<tr><td rowspan="2">Newly planted tree crops</td><td>Olives</td><td>Grassland</td><td>10,000</td></tr>
<tr><td>200 ha: almond and fig tree</td><td>Grassland</td><td>200 ha: almond and fig tree</td></tr>
<tr><td rowspan="3">C.R.D.A Jendouba</td><td>Improved tree crops</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td rowspan="2">Newly planted tree crops</td><td>Olives</td><td>Set aside</td><td>1,500</td></tr>
<tr><td>Grenadiers</td><td>Annual crops</td><td>26</td></tr>
<tr><td rowspan="4">C.R.D.A Kasserine</td><td>Improved tree crops</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td rowspan="3">Newly planted tree crops</td><td>Olives</td><td>Set aside</td><td>2,200</td></tr>
<tr><td>Apple tree</td><td>Set aside</td><td>45</td></tr>
<tr><td>Almond</td><td>Set aside</td><td>50</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">15,551 ha</td></tr>
</table>

6. Discussion: Overall performance of the suitable tools

367) This study compares GHG Accounting Tools for SLM. It examines the tools' performance, GHG coverage, suitability per SLM activities, and comparability of results. To confirm, reduce, or eliminate the tools activities scope, mapping the tools within the wide range of potential carbon sequestration and GHG emission reduction activities is crucial. Critical variables identified contributed to conclusions on the relative transparency, completeness, and consistency of each tool. These conclusions are summarized in the detailed characterization of the tools and in the analysis of tools coverage and performances per activity. The analysis found that it is important to assess tool coverage and results per SLM activity to judge their ability to measure GHG emissions from non-vegetative surfaces to cropland, grassland, and forest cover.

6.1 Review of the detailed characterization of suitable tools

368) Only five out of seven short-listed tools were identified as suitable for a wide range of SLM GHG assessment: AFOLU Carb, AFD-CFT, CAT-AR, CBP, and EX-ACT. The data, time and skill requirements are shown in Table 36, as there is no difference among the tools in terms of availability and geographic coverage. All calculators account for soil and climate differences and have relatively moderate data, time, and skills requirements, with the implication that more training may be required for users.

369) Concerning GHG coverage, only three out of the five suitable tools account for CO_2, N_2O, and CH_4 collectively. Except for the CAT-AR tool, each tool accounts for leakage. Only CBP and EX-ACT quantify uncertainties in their GHG evaluation. Except for the CAT-AR tool, the tested GHG accounting tools are not specifically designed for carbon markets. All the tools follow the IPCC and stock difference methods. The carbon pools considered within each calculator vary; however, all short-listed calculators account for above-ground and below-ground biomass.

Table 36: Data, time, and skills requirements of the suitable tools

No.	Tool	Data requirements	Time requirements	Skills requirements
1	AFD-CFT	+++	++	+
2	AFOLU Carb	+++	+++	+++
3	CAT-AR	++	+++	++
4	CBP	+++	+++	+
5	EX-ACT	+++	++	++
Legend		+ +++to +; from low data requirements to medium/high/very high data requirements	0 min < Time necessary ≤ 10 min → ++++ 10 min < Time necessary ≤ 20 min → +++ 20 min < Time necessary ≤ 30 min → ++ Time necessary > 30 min → +	++++ to +; from basic skills requirements to medium/high/very high skills requirements

Table 37: Analysis type, IPCC GHG accounting approaches, GHG, carbon pools, uncertainty and leakage accounted for by the suitable tools

Tool	Analysis type		IPCC GHG accounting approaches		GHG			Carbon pools					Uncertainty	Leakage
	Ex ante	Ex post	IPCC Tier used (1, 2)	Gain-loss and Stock difference methods	CO_2	N_2O	CH_4	Above-ground	Below-ground	Litter	Dead wood	Soil Carbon		
AFD-CFT	x	x	x	x	x	no	x	x	x	no	no	x	no	x
AFOLU Carb	x	no	x	x	x	no	no	x	x	no	no	x	no	x
CAT-AR	x	x	x	x	x	x	x	x	x	no	no	no	no	x
CBP	x	x	x	x	x	x	x	x	x			x	x	x
EX-ACT	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x means the tool meets the criteria, no means it does not

6.2 Tools coverage and performance relative to SLM activities

370) Table 38 summarizes the suitable tools with respect to the prevalence of SLM activities in the GEF projects. The circumstances under which the tools are suitable are discussed in the following paragraphs.

Table 38: Tools and frequency of SLM activities assessed

SLM activity	Frequency	GHG accounting tools suitable
Afforestation	10	EX-ACT, CBP, AFD-CFT, AFOLU Carb, and CAT-AR
Deforestation	4	EX-ACT, CBP, AFOLU Carb, and CAT-AR
Forest management	8	EX-ACT, CBP, and AFOLU Carb
Perennial crops	9	EX-ACT, CBP, AFD-CFT, and CFT
Annual crops	8	EX-ACT, CBP, AFD-CFT, AFOLU, CCAFS, and CFT
Grassland management	7	EX-ACT, CBP, AFOLU Carb, and AFD-CFT
Livestock	2	EX-ACT and CBP
Inputs (Fertilizers and Pesticides)	1	EX-ACT and AFD-CFT
Investments	4	EX-ACT and AFD-CFT

6.2.1 Afforestation and reforestation activities

371) Ten afforestation activities were identified and assessed across the GEF projects (Table 38). Four tools—EX-ACT, CBP, AFD-CFT and CAT-AR—are judged suitable for afforestation GHG balance analysis. Depending on the ILU, the following GHG calculators are recommended for both Tier 1 and Tier 2 methodologies:

- **The EX-ACT tool**, when the ILU is annual cropland, perennial cropland, flooded rice, grassland, set aside land, degraded land, other land, wetlands or settlements.
- **The CBP tool**, when the ILU is annual cropland, perennial cropland, flooded rice, grassland, or settlements.
- **The AFD-CFT tool**, when the ILU is annual cropland, perennial cropland, set aside land, grassland, other land, or settlements.
- **The CAT-AR tool**, when the ILU is cropland or grassland.
- **EX-ACT**, **CBP**, and **AFD-CFT** tools when afforestation activities are carried out in the baseline/business as usual scenario.

6.2.2 Deforestation activities

372) Four deforestation activities were identified and assessed (Table 38). Three tools, EX-ACT, CBP, and AFD-CFT, are judged suitable for the deforestation GHG balance analysis. Depending on the FLU, the following GHG calculators are recommended for both Tier 1 and Tier 2 methodologies:

- **The EX-ACT tool**, when the FLU is annual cropland, perennial cropland, flooded rice, grassland, set aside land, degraded land, other land, wetlands, or settlements
- **The CBP tool**, when the FLU is annual cropland, perennial cropland, flooded rice, grassland, or settlements
- **The AFD-CFT tool**, when the FLU is annual cropland, perennial cropland, set aside land, grassland, other land, or settlements

6.2.3 Forest management

373) Eight forest management activities were identified and assessed (Table 38). Within this study, two forest management categories were identified for GHG balance analysis: *forest fire management* and *forest management and degradation* (Table 13). Depending on the type of forest management activities, the following GHG calculators are recommended for both Tier 1 and Tier 2 methodologies:

- The **EX-ACT**, **CBP**, and **AFOLU Carb tools**, for forest fire management GHG analysis
- The **EX-ACT** and **CBP tools**, for all forest management GHG analysis.

6.2.4 Annual cropland

374) Eight annual crops activities were identified and assessed (Table 38). Within this study, two annual crops categories were identified for GHG balance analysis: newly implemented systems after land conversion (LUC) and annual systems that remain annual systems (Table 13).

375) For newly implemented systems and depending on the ILU, the following GHG calculators are recommended for both Tier 1 and Tier 2 methodologies:

- **The EX-ACT tool**, when the ILU is forestland, perennial cropland, flooded rice, grassland, set aside land, degraded land, other land, wetlands, or settlements
- **The CBP tool**, when the ILU is forestland, perennial cropland, flooded rice, grassland, or settlements
- **The AFD-CFT tool,**[37] when the ILU is forestland, perennial cropland, set aside land, grassland, other land, or settlements

376) For GHG analysis of annual systems that remain annual systems, the **EX-ACT** and **CBP** tools are recommended when considering improved management practices scenario for both Tier 1 and Tier 2 methodologies.

6.2.5 Perennial cropland

377) Nine perennial crops activities were identified and assessed (Table 38). Within this study, two perennial crops categories were identified for GHG balance analysis: *newly implemented systems* after land conversion (LUC) and *perennial systems that remain perennial systems* (Table 13). For both categories, the following tools are recommended for both Tier 1 and Tier 2 methodologies:

- **The EX-ACT tool,**[38] when the ILU is forestland, annual cropland, flooded rice, grassland, set aside land, degraded land, other land, wetlands, or settlements
- **The CBP tool**, when the ILU is forestland, annual cropland, perennial cropland, flooded rice, or settlements
- **The AFD-CFT tool,**[32] when the ILU is forestland, cropland, set aside land, grassland, other land, or settlements

6.2.6 Grassland management

378) Seven grassland activities were identified and assessed (Table 38). Within this study, two grassland categories were identified for GHG balance analysis: *newly implemented systems* after land conversion (LUC) and *grassland systems that remain grassland systems* (Table 13).

379) For *newly implemented grassland systems* and depending on the ILU, the following GHG calculators are recommended for both Tier 1 and Tier 2 methodologies:

- **The EX-ACT tool**, when the ILU is forestland, annual cropland, perennial cropland, flooded rice, set aside land, degraded land, other land, wetlands, or settlements.
- **The CBP tool**, when the ILU is forestland, annual cropland, perennial cropland, or other land. The CBP DA is recommended for the analysis as default coefficients could be replaced to describe the set aside and degraded land EFs and carbon stocks values.

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[37] Restricted agricultural management practices.
[38] The tool is suitable for perennial crops improvement.

- **The AFD-CFT tool**, when the ILU is forestland, annual cropland, perennial cropland, set aside land, other land, or settlements.

380) For GHG analysis *of grassland systems that remain grassland systems,* the **EX-ACT**, **CBP**, **AFOLU Carb,** and **AFD-CFT** tools are recommended when considering improved management practices for both Tier 1 and Tier 2 methodologies.

6.2.7 Livestock

381) Two grassland activities were identified and assessed (Table 38). Based on the analysis results, the use of the **EX-ACT** tool is recommended for livestock GHG analysis when considering technical mitigation options (feeding practices, specific agents, and breeding practices).[39]

6.2.8 Inputs management (fertilizers and pesticides)

382) Only one fertilizer management activity was identified and assessed (Table 38). Based on the analysis results, the use of the **EX-ACT** tool is recommended for GHG balance analysis (N_2O emissions from managed soils, CO_2 emissions from lime and urea application).

383) No pesticides management activities were identified. However, the use of the **EX-ACT** tool is recommended for GHG balance analysis of pesticides management.

6.2.9 Investments

384) Four investments activities were identified and assessed (Table 38). Within this study the GHG emissions covered by the 'investments' are (a) GHG emissions associated with electricity consumption, (b) GHG emissions associated with fuel consumption, (c) GHG emissions associated with installation of irrigation systems, and (d) GHG emissions associated with building of infrastructure (Table 13). Depending on the investments activities, the following tools are recommended for both Tier 1 and Tier 2 methodologies:
   - **The EX-ACT tool**, when considering GHG emissions related to electricity and fuel consumption, irrigation system construction, or agricultural building activities.
   - **The AFD-CFT tool**, when considering GHG emissions related to electricity and infrastructure and agricultural building construction.

6.2.10 Versatility of the tools

385) Table 39 identifies the EX-ACT, CBP, and AFD-CFT tools as the most versatile tools capable of addressing most land use activities. The least versatile tools are the CAT-AR

[39] For users intending to use detailed Tier 2 (for example, refined EFs on enteric fermentation), a link is provided by the EX-ACT tool to the FAO GLEAM-I tool. The CBP DA could be used to add in livestock EFs.

and AFOLU Carb because they were developed to address specific SLM activities. Table 39 also demonstrates that most calculators account for land use change (that is, a change from one land use category to another—forestland, cropland, grassland, flooded, other land, degraded land). Table 40 highlights the recommended tools (EX-ACT, CBP, and/or AFD-CFT) when considering different land use change scenarios.

Table 39: Recommended tools per land use activity

No.	Tool	SLM activities															Score (%)
				Forest management		Annual crops		Perennial crops		Grassland		Inputs, energy, and infrastructure					
		Afforestation/reforestation*	Deforestation*	Fire forest management	Forest management and degradation	Annual crops development*	Annual crops improvement	Perennial crops development*	Perennial crops improvement	Grassland development*	Grassland improvement	Inputs (fertilizers and pesticides)	Electricity consumption	Fuel consumption	Irrigation systems	Infrastructure	
1	AFD-CFT	x	x	no	no	x	no	x	x	x	x	no	x	no	no	x	60
2	AFOLU Carb	no	no	x	no	no	no	no	no	no	x	no	no	no	no	no	13
3	CAT-AR	x	no	no	no	no	no	no	no	no	no	no	no	no	no	no	6
4	CBP	x	x	x	x	x	x	x	x	x	x	no	no	no	no	no	66
5	EX-ACT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100

Note: *The choice of the appropriate tool is conditioned by the different land uses considered when considering LUC scenarios.

x means the tool meets the criterion; no means the tool does not. Score is the number of activities out of 15 for which a tool is suitable, expressed in percent.

Table 40: Recommended tools when considering land use change scenarios

FLU \ ILU	Forestland	Annual crops	Perennial crops	Grassland	Flooded rice	Set aside land	Degraded land	Other land	Settlements
Forestland		AFD-CFT CAT-AR CBP EX-ACT	AFD-CFT CAT-AR CBP EX-ACT	AFD-CFT CAT-AR CBP EX-ACT	EX-ACT	AFD-CFT CAT-AR EX-ACT	EX-ACT	EX-ACT	CBP EX-ACT
Annual crops	AFD-CFT CBP EX-ACT		AFD-CFT CBP EX-ACT	AFD-CFT CBP EX-ACT	EX-ACT	AFD-CFT EX-ACT	EX-ACT	EX-ACT	CBP EX-ACT
Perennial crops	AFD-CFT CBP EX-ACT	AFD-CFT CBP EX-ACT		AFD-CFT CBP EX-ACT	EX-ACT	AFD-CFT EX-ACT	EX-ACT	EX-ACT	CBP EX-ACT
Grassland	AFD-CFT CBP EX-ACT	AFD-CFT CBP EX-ACT	AFD-CFT CBP EX-ACT		EX-ACT	AFD-CFT EX-ACT	EX-ACT	EX-ACT	CBP EX-ACT
Flooded rice	EX-ACT	EX-ACT	EX-ACT	EX-ACT		EX-ACT	EX-ACT	EX-ACT	EX-ACT
Set aside land	AFD-CFT EX-ACT	AFD-CFT EX-ACT	AFD-CFT EX-ACT	AFD-CFT EX-ACT	EX-ACT		EX-ACT	EX-ACT	EX-ACT
Degraded land	EX-ACT	EX-ACT	EX-ACT	EX-ACT	EX-ACT	EX-ACT		EX-ACT	EX-ACT
Other land	CBP EX-ACT	CBP EX-ACT	CBP EX-ACT	CBP EX-ACT	EX-ACT	EX-ACT	EX-ACT		EX-ACT
Settlements	CBP EX-ACT	CBP EX-ACT	CBP EX-ACT	CBP EX-ACT	EX-ACT	EX-ACT	EX-ACT	EX-ACT	

6.3 Comparison of results between tools

386) The comparability of the assessment results depends on the land use activity as each tool has its own purpose. There is no widely accepted international standard or protocol for GHG assessment and monitoring at the local level yet. In the absence of any such standard, all the short-listed calculators have used the IPCC methodology for national inventories as a guideline. As such, the accuracy of a tool largely depends on the IPCC methods used and the data that feed into it. The Tier 1 methods are based on least accurate methods, Tier 2 methods are more accurate methods, where EFs and carbon stock changes are available.

The Tier 3 methods are very detailed, where biophysical models of GHG processes that are developed at the country or regional level are available.

387) This raises the question as to whether the desk study analysis based on project documents and Tier 1 methods disposes of comprehensive and reliable datasets for the compilation of GHG assessment. Table 41 compiles differences in results between tools for both analysis: the desk study using Tier 1 methodology and the in-depth analysis using Tier 2 methodology. All the SLM activities, besides deforestation and forest fire management, were assessed under both desk study and in-depth analysis. For both activities, and to complete the analysis, default values were substituted by Tier 2 coefficients to describe the type of vegetation and their associated carbon stock values.

Table 41: Comparison of results: Desk study, Tier 1 methodology versus in-depth analysis, Tier 2 methodology

Activities		Tools	Desk study analysis, Tier 1 methodology	In-depth analysis, Tier 2 methodology
*Afforestation/reforestation		CBP & EX-ACT	+	+
		AFD-CFT & EX-ACT	+	+
		CAT-AR & EX-ACT	+	+
		AFD-CFT & CBP	+++	+
		CAT-AR & CBP	+	+
		AFD-CFT & CAT-AR	+++	+
Deforestation		CBP & EX-ACT	++++	++
		AFOLU Carb & EX-ACT	+++	+
		AFOLU Carb & CBP	++++	++
Forest management	Forest fire management	EX-ACT & CBP	++	+
		AFOLU Carb & EX-ACT	+++	+
		AFOLU Carb & CBP	+++	+
	Forest management	CBP & EX-ACT	++	+
Annual Cropland	Annual cropland development	CBP & EX-ACT	++	+
		AFD-CFT & EX-ACT	++	++
		AFD-CFT & CBP	++	+
	Annual cropland improvement	CBP & EX-ACT	++++	+
Perennial cropland	Perennial cropland development	CBP & EX-ACT	+++	++
		AFD-CFT & EX-ACT	++++	++
		AFD-CFT & CBP SA	++++	++
	Perennial cropland improvement*	CBP & EX-ACT	+	
		EX-ACT & AFD-CFT	+	
		CBP & AFD-CFT	+	

Activities		Tools	Desk study analysis, Tier 1 methodology	In-depth analysis, Tier 2 methodology
Grassland	Grassland management	CBP & EX-ACT	++	++
		AFD-CFT & EX-ACT	+++	++
		AFOLU Carb & EX-ACT	+++	++
		AFD-CFT & CBP	+++	+
		AFOLU Carb &CBP	+++	+
		AFD-CFT & AFOLU Carb	+++	+
	Grassland development	AFD-CFT & EX-ACT	++	+
Livestock		CBP & EX-ACT	+	+
Inputs and infrastructures		AFD-CFT & EX-ACT	+**	
Legend		0 percent < results difference ≤ 5 percent → + 5 percent < results difference ≤ 10 percent → ++ 10 percent < results difference ≤ 20 percent → +++ results difference > 20 percent → ++++		

Note:
*The analysis was conducted following Tier 2 methodology with default Tier 1 coefficients replaced to describe the initial and final (after improvements) above-ground growth rate (tC per ha per year)
** A minimal difference was observed among the results, owing to the similarities in investment and input EFs used by the tools.

6.3.1 Results analysis

388) The most versatile results differences were observed within the desk study analysis. This is explained mainly by the use of the Tier 1 accounting approach and the type of carbon pools taken into account by each tool. The highest result differences (more than 20 percent) were observed when analyzing deforestation, perennial cropland development, and annual cropland improvement activities. The less versatile results differences (less than 20 percent) were associated with afforestation/reforestation, forest management, annual cropland development, perennial cropland improvement, livestock, and inputs and infrastructures GHG accounting assessment.

389) For the in-depth analysis, including data collected at the local level in Tunisia and Chile provided more accuracy than the desk study analysis. The differences in results decreased significantly (to less than 10 percent) when the data collected reflected more detailed descriptions of the projects' activities and their associated EFs and carbon stock values.

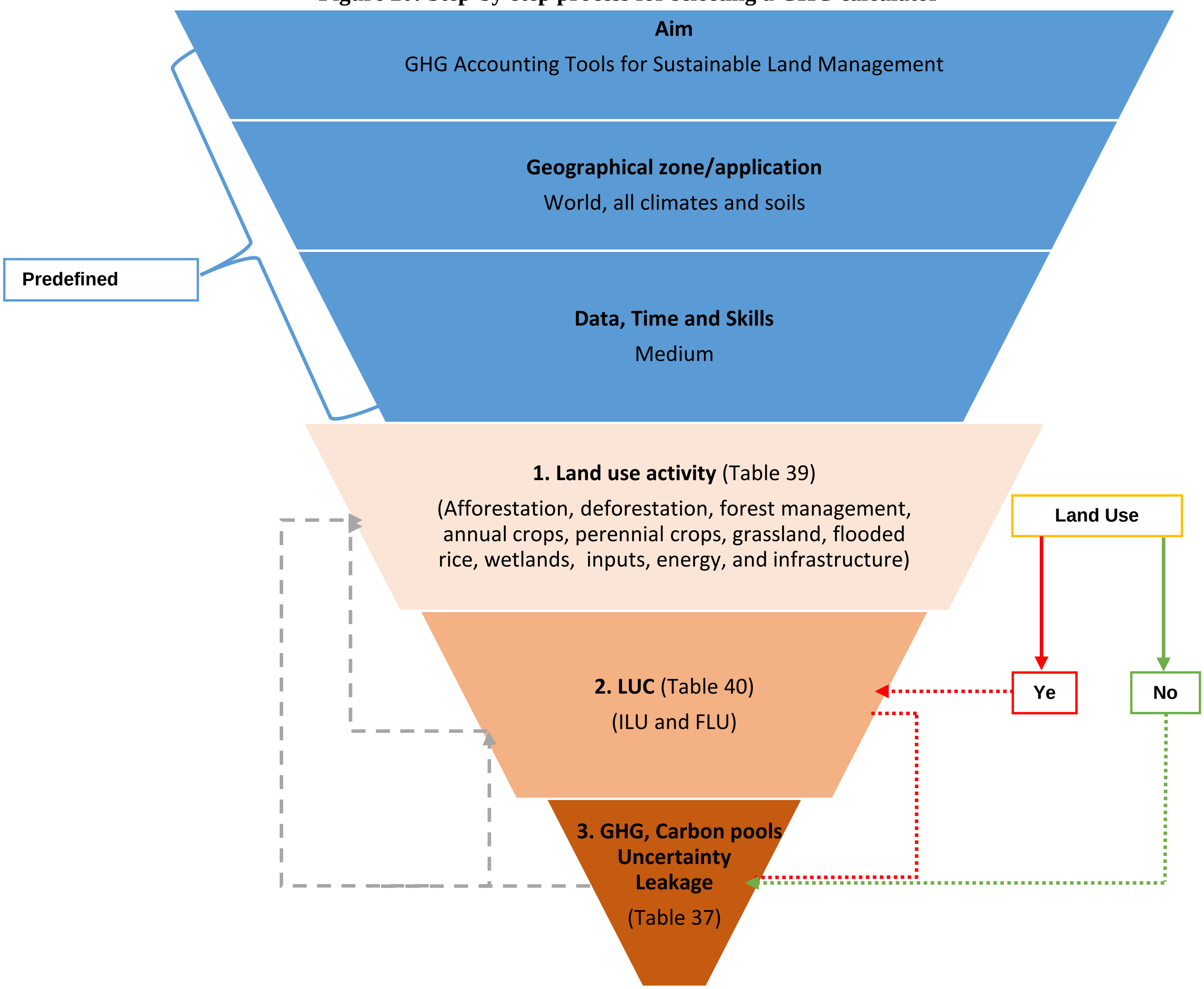
390) The uncertainty level furthermore validates the different results as the degree of uncertainty was estimated at less than 21 percent within the in-depth analysis, compared to higher uncertainty levels when running a desk study analysis (for example, 62 percent, Biodiversity Conservation in Cacao Agroforestry Project in Costa Rica).

6.4 Multicriteria GHG tool selector for SLM Projects

391) Following the analyses, we present in this section a set of criteria for selecting a tool for a given SLM project. The three-step process also reflects the characteristics and purpose of the tool (Figure 20).

- **Step 1:** Choose the land use activity (afforestation, deforestation, forest management, annual cropland, perennial cropland, grassland, flooded rice, wetlands, inputs, energy, and infrastructure) (Table 39).
- **Step 2:** If any LUC activity is foreseen, choose ILU and FLU. (Table 40).
- **Step 3:** Consider other criteria as needed to recommend the appropriate GHG tool(s) (for example, the GHGs [CO_2, N_2O, CH_4], the IPCC GHG accounting approaches, the need for multiple areas to be analyzed simultaneously, carbon pools, the need for spatially explicit results, uncertainties, and leakages, and so on) (Table 37). Note that additional requirements can be used to reduce the selection to one or two calculators.

Figure 20: Step-by-step process for selecting a GHG calculator



7. Conclusions and recommendations

392) Climate change poses a major challenge to the agricultural sector due to the dependence of agriculture on climate and the complex role it plays in rural, social, and economic contexts (Hatfield et al. 2011). According to the FAO (2002), the rising incidence of weather extremes will have increasingly negative impacts on crop productivity, especially if occurring at sensitive stages in crop life cycles (National Climate Assessment 2014). Furthermore, the IPCC, in its fifth assessment report, predicts that climate change will affect food security by the mid-21st century. However, climate change can offer new opportunities for productive and SLM practices. Improved land management practices can play an important role in mitigating GHG emissions by removing substantial volumes of carbon from the atmosphere and sequestering them in soils and plant tissues.

393) Systematic assessments are required to make informed decisions, and therefore, tackle climate-induced vulnerability and food insecurity. The quantification of GHG emissions and carbon sequestration is a necessary step for SLM. GHG accounting can provide the numbers and data that are key for informed decision making. It can help identify management practices and opportunities that reduce GHG emissions while also providing improved food security, more resilient production systems, and better rural livelihoods. Estimates of this potential should consider the full GHG balance, including possible combinations of different activities and practices that could affect the net climate change mitigation potential.

394) This study has shown that many advanced tools have been developed, the main methodological approaches and challenges of GHG accounting have been highlighted, and an analytical framework for the selection of the appropriate carbon accounting tools for SLM activities has been presented. The analysis was user driven to understand the underlying particularities of each tool and their differences and enable the user to make the final choice on the GHG calculator(s). In general, the methodologies applied by the tools are relatively similar and all tool developers align their methodology with the IPCC guidelines. The tools are moderately data, skills, and time demanding and offer many additional functions (carbon footprint, socioeconomic analysis, and so on). The methodologies on which the tools are based are transparent and detailed in guidance documents.

395) The accuracy of the different quantification methods is classified in three tiers, Tier 1 methods being the least accurate methods. The accuracy of the method depends on the EFs and the activity data used. Region-specific EFs and activity data are more accurate than country-specific EFs and should preferably be used. Nevertheless, other aspects should be considered to provide the users with tools that are comprehensible, standardized, robust, and applicable to SLM projects.

396) This study clearly shows that the completeness aspect is key in comparing the tools: GHG assessments are not always reported for all relevant categories of sources and sinks and GHGs. Some tools cover only some land use activities whereas other tools cover almost all land use activities. Furthermore, scope definitions vary and the number and type of GHG covered differ across tools. As such, it is recommended to extend the scope of the calculators while restricting the data, skills, time needed, and increasing their accuracy. For the international dissemination of these tools, their availability in different languages is of crucial importance.

397) The accuracy of a tool depends mainly on the data that feed into it. Thus, it depends on data availability at the local level, on the one hand, and on support of the users and advice on how to find data, on the other. All tools offer the option to specify Tier 2 values, country-specific EFs. Desk studies analysis based on project documentation is often lacking comprehensive and reliable datasets for the compilation of GHG assessment, which will increase/decrease the level of certainty/uncertainty. Data collection and quality assurance at the local level is therefore recommended**.**

398) It is important to bear in mind that the main question is not whether a calculator is suitable. On the contrary, most actors would welcome any development toward greater tools completeness and accuracy. A recent FAO publication[40] encourages the development of new tools and the dissemination of existing tools to assist with the analysis of, and the planning for, the impacts of climate change and new national reporting requirements. In this prospect, advocacy for large-scale climate finance to be funnelled into the sectors where investment can lay the groundwork for the paradigm shift is needed to achieve the future we want.

[40] FAO Strategy on Climate Change, available at http://www.fao.org/3/a-i7175e.pdf

Annex: Detailed Results of Carbon Balance Appraisals

Project ID	GEF ID	Country	Project name	Components of the project	Review by activity and by GHG Tool (in tCO_2-e/Year)						
P147760	6947	Belarus	Forestry Development Project	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation) on perennial	-7227	-7,624	-7,879	-9,537	-3,371	N/A	N/A
				Degradation and management (forest degradation)	-8801	-8,922	-7,622	N/A	N/A	N/A	N/A
				Inputs & Investments	-123279.033	N/A	N/A	-123,284	N/A	N/A	N/A
				Total	-2,786,149	-330,920	-152,441	-2,656,404	-67,425	-	-
				Total per year	-139,307	-16,546	-7,622	-132,820	-3,371	-	-
				Per hectare	-3.603330261	-	-	-3	-	-	-
				Per hectare per year	0	-	-	-0.2	-	-	-
P086341	2450	Brazil	BR GEF Rio Grande do Sul Biodiversity	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Grassland and Livestock (Grassland management)	-227,027	-225,620	-162,645	-170,000	N/A	N/A	N/A
				Total	-4,540,540	-4,512,400	-3,252,900	-3,400,000	-	-	-
				Total per year	-227,027	-225,620	-162,645	-170,000	-	-	-
				Per hectare	-21.22	-21.1	-27.47	-28.71	-	-	-
				Per hectare per year	-1.06	-1.1	-1.37	-1.44	-	-	-
P070867	2450	Brazil	Caatinga Conservation and Sustainable Management Project	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-28,032	-24,509	-34,194	-42,800	-39,281	N/A	N/A
				Agriculture (Annual)	-544	-475	-42	-200	N/A	-1,684	-304
				Agriculture (Perennial)	-8,357	-7,306	N/A	-2,900	N/A	N/A	-197
				Total	-738,642	-645,810	-684,720	-918,000	-785,615	-	-
				Total per year	-36,932	-32,291	-34,236	-45,900	-39,281	-	-

				Per hectare	-371.2	-324.5	-	-461.31	-	-	-
				Per hectare per year	-18.6	-16.2	-	-23.07	-	-	-
P130568	5187	Burkina Faso	GGW: Community based Rural Development Project 3rd Phase with Sustainable Land and Forestry Management in Burkina Faso	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Deforestation)	-7,225	-7,668	-7,511	-7,290	N/A	N/A	N/A
				Management and degradation (forest degradation)	-2,491	-2,652	N/A	N/A	N/A	N/A	N/A
				Total	-194,323	-206,401	-150,214	-145,800	-	-	-
				Total per year	-9,716	-10,320	-7,511	-7,290	-	-	-
				Per hectare	-13	-14	-10	-10	-	-	-
				Per hectare per year	-1	-1	-1	-1	-	-	-
P127258	4631	Burundi	Watershed App to Sust Coffee Production	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-4,765	-5,441	-5,463	-4,900	-4,746	N/A	N/A
				Agriculture (Perennial)	-43,986	-63,260	N/A	-56,000	N/A	N/A	-4,048
				Degradation and Management (forest degradation)	-4,112	-3,614	-5,890	N/A	N/A	N/A	N/A
				Total	-1,057,260	-1,266,004	-227,060	-1,218,000	-94,910		-80965.8
				Total per year	-52,863	-63,300	-11,353	-60,900	-4,746	-	-4048.29
				Per hectare	-171	-21.7	-	-612.06	-		
				Per hectare per year	-8.5	-1.1	-	-30.6	-		
P087318	2634	China	Guangxi Integrated Forestry Development and Biodiversity Conservation	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-2,620,688	-7,641,060	-3,771,511	-3,200,000	-3,564,792	N/A	N/A
				Total	-52,413,767	-152,821,200	-75,430,220	-64,000,000	-71,295,849	-	-
				Total per year	-2,620,688	-7,641,060	-3,771,511	-3,200,000	-3,564,792	-	-

				Per hectare	-244.92	-714.1	- 636.9988 599	- 540.4720 686	- 602.0846 13	-	-
				Per hectare per year	-12.25	-35.7	-31.85	-27.02	-30.1	-	-
P0903 76	322 3	China	Shanghai Agricultural and Non-point Pollution Reduction Project	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Livestock	-5,394	-5,862	0	N/A	N/A	N/A	0
				Total	-107,888	-117,240	-	-	-	-	0
				Total per year	-5,394	-5,862	-	-	-	-	0
				Per hectare	-34	0	-	-	-	-	0
				Per hectare per year	-1.7	0	-	-	-	-	0
P0613 15	979	Costa Rica	Project Biodiversity cacao agroforestry Costa Rica	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-2,548	-2,207	-2,850	-3,300	- 2,389.29	N/A	N/A
				Agriculture (perennial)	-4,708	-4,840	N/A	-4,600	N/A	N/A	N/A
				Total	-145,116	-140,940	-57,000	-158,000	-47,786	- 34,684	- 34,684
				Total per year	-7,256	-7.047	-2,857	-7,900	-2,390	-1,734	-1,734
				Per hectare	-109	-105.6	-43	-118	-36	-26	-26
				Per hectare per year	-5	-5.28	-2	-6	-2	-1	-1
P0907 89	463 0	Ethiopia	Country Program for Sustainable Land Management (ECPSLM)	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	- 1,079,287	- 1,121,464	-783,933	- 1,450,000	- 1,348,056	N/A	N/A
				Agriculture (Annual)	-659,046	-324,000	-572,747	-274,000	N/A	- 301,605	- 368,666
				Agriculture (Perennial)	- 1,017,526	-986,632	N/A	-410,000	N/A	N/A	- 543,000
				Grassland and Livestock (Grassland management)	-342,098	-380,000	-481,386	-380,000	N/A	N/A	N/A
				Degradation and Management (forest degradation)	-78,794	-73,850	-134,367	N/A	N/A	N/A	N/A
				Inputs & Investments	101,665	N/A	N/A	3,600	N/A	N/A	N/A
				Total	- 66,317,269	- 57,718,910	- 36,761,323	- 49,560,000	- 26,961,120	-	-

				Total per year	-3,315,863	-2,885,945.50	-1,838,066	-2,478,000	-	-	-
				Per hectare	-59.7	-51.9	-	-	-	-	-
				Per hectare per year	-3	-2.6	-	-	-	-	-
P081297	1877	Guinea	Community-based Land Management	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Deforestation)	-88,541	-98,530	-76,650	-101,000	N/A	N/A	N/A
				Agriculture (Annual)	-13,921	-10,081	-10,081	-11,000	N/A	-9,500	10,500
				Agriculture (Perennial)	-138,151	-118,728	N/A	-90,000	N/A	N/A	75,200
				Degradation and Management (forest degradation)	-13,756	-15,168	-15,778	N/A	N/A	N/A	N/A
				Total	-5,087,380	-4,850,140	-1,734,620	-4,040,000	-	-	-
				Total per year	-254,369	-242,507.00	-86,731	-202,000	-	-	-
				Per hectare	-102.2	-97.4	-	-	-	-	-
				Per hectare per year	-5.1	-4.9	-	-	-	-	-
P075534	1214	Jordan	Integrated Ecosystem Management in the Jordan Rift Valley	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Change (set aside land converted to grassland)	-214,679	-85,697	N/A	-175,000	N/A	N/A	N/A
				Total	-4,293,575	-1,713,940	-	-3,500,000	-	-	-
				Total per year	-214,679	-85,697	-	-175,000	-	-	-
				Per hectare	-118.9	-47.5	-	-96.9	-	-	-
				Per hectare per year	-5.9	-2.4	-	-4.85	-	-	-
P129516	5270	Mali	Natural Resources Management in a Changing Climate	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Deforestation)	-37,175	-21,317	-42,779	-45,000	N/A	N/A	N/A
				Land Use Changes (Afforestation)	-1,218	-5,738	-10,780	-9,344	-11,300	N/A	N/A
				Agriculture (Annual)	-2,383	-8,499	-5,040	-6,500	N/A	-1,003	-1,226

				Grassland and Livestock (Grassland management)	-158,833	-169,980	-156,426	-195,900	N/A	N/A	N/A
				Total	-3,992,189	-4,110,680	-4,300,499	-4,818,000	-	-	-
				Total per year	-199,609	-205,534	-215,025	-240,900	-	-	-
				Per hectare	-34	-70.4	-36.3	-40.7	-	-	-
				Per hectare per year	-1.7	-3.5	-1.8	-2	-	-	-
P118518	4630	Moldova	Agriculture Competitiveness Project	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Agriculture (Annual)	-5,682	-15,189	-5,504	-5,200	N/A	-3314.34	-4051
				Agriculture (Perennial)	-4,811	-5,427	N/A	-5,000	N/A	N/A	-3598
				Total	-209,855.02	-412,320	-110,080	-204,000	-	-	-
				Total per year	-10,492.75	-15,189.00	-5,504	-10,200	-	-	-
				Per hectare	-20.99	-41.232	-25.5	-20.4	-	-	-
				Per hectare per year	-1.05	-2.0616	-1.3	-1.02	-	-	-
P129774	5292	Morocco	GEF Social and Integrated Agriculture (ASIMA)	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Agrforestry) + Agriculture (perennial)	-373,063	-258,335	N/A	-370,000	N/A	N/A	N/A
				Agriculture (Annual)	-4,772	-3,254	-7,965	-2,500	N/A	-2,432	-3,818
				Livestock	-33	0	-1,238	N/A	N/A	N/A	N/A
				Total	-7,557,368	-5,231,783	-184,060	-7,450,000	-	-	-
				Total per year	-377,868	-261,589	-9,203	-372,500	-	-	-
				Per hectare	-130	-89.7	-	-	-	-	-
				Per hectare per year	-6.5	-4.5	-	-	-	-	-
P635621	9089	Serbia	Contribution of Sustainable Forest Management to a Low Emission and Resilient Development	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-65,434	-86,124	-24,674	-58,900	-49,211	N/A	N/A
				Land Use Changes (Deforestation)	21,466	29995	14,881	13,000	N/A	N/A	N/A

				Degradation and Management (forest degradation)	-54,246	N/A	N/A	N/A	N/A	N/A	N/A
				Total	-1,964,280	-2,322,380	-195,869	-918,000	-	-	-
				Total per year	-98,214	-116,119	-9,793	-45,900	-	-	-
				Per hectare	-16	-23.2238	-	-	-	-	-
				Per hectare per year	-0.8	-1.16119	-	-	-	-	-
P613134	4583	Turkey	Sustainable land Management and Climate-Friendly Agriculture	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Agriculture (Annual)	-19,743	-21,545	-26,966	-30,000	N/A	N/A	N/A
				Degradation and Management (forest degradation)	-43,682	-59,145	N/A	N/A	N/A	N/A	N/A
				Grassland and Livestock (Grassland management)	-103,398	-118,290	-121,278	-97,000	N/A	N/A	N/A
				Total	-3,336,460	-3,979,588	-2,964,880	-2,540,000	-	-	-
				Total per year	-166,823	-198,979.40	-148,244	-127,000	-	-	-
				Per hectare	-33.4	-39.8	-	-	-	-	-
				Per hectare per year	-1.7	-2	-	-	-	-	-
P085621	4140	Chile	Sustainable Land Management Project	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-10,340	-8,684	-11,145	-8,171	-7,801	N/A	N/A
				Degradation and Management (forest degradation)	-7,611	-6,423	N/A	N/A	N/A	N/A	N/A
				Grassland and Livestock (Grassland management)	-208	-56	-222	233	N/A	N/A	N/A

				Total	-363,184	-303,269	-227,333	-158,771	-	-	-
				Total per year	-18,159	-15,163.50	-11,367	-7,939	-	-	-
				Per hectare	-3	-3	-	-	-	-	-
				Per hectare per year	-0.1	-0.2	-	-	-	-	-
P112568	3669	Tunisia	TUN GEF Second Natural Resources Management	Tools	EX-ACT	CBP	AFOLU Carb	AFD CFT	CAT-AR	CCA FS	CFT
				Land Use Changes (Afforestation)	-111,322	-70,968	-67,888	-93,200	-118,663	-118,067	-118,067
				Agriculture (Perennial)	-106,487	-168,740	N/A	-132,900	N/A	N/A	N/A
				Grassland and Livestock (Grassland management)	-7,838	-14,667	-3,523	-4,400	N/A	N/A	N/A
				Inputs & Investments (construction of irrigation systems on 4,000 ha)	12	N/A	N/A	N/A	N/A	N/A	N/A
				Total	-4,512,700	-5,087,500	-1,428,220	-4,610,000	-	-	-
				Total per year	-225,635	-254,375.00	-71,411	-230,500	-	-	-
				Per hectare	-179.4	-202.3	-	-	-	-	-
				Per hectare per year	-9	-10.1	-	-	-	-	-

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